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OIL CROPS: PROCEEDINGS OF THE THREE MEETINGS HELD AT PANTNAGAR AND HYDERABAD, INDIA, 4 – 17 JANUARY 1989

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This series includes meeting documents, internal reports, and preliminary technical documents that may later form the basis of a formal publication. A Manuscript Report is given a small distribution to a highly specialized audience.

La présente série est réservée aux documents issus de colloques, aux rapports internes et aux documents techniques susceptibles d'être publiés plus tard dans une série de publications plus soignées. D'un tirage restreint, le rapport manuscrit est destiné à un public très spécialisé.

Esta serie incluye ponencias de reuniones, informes internos y documentos técnicos que pueden posteriormente conformar la base de una publicación formal. El informe recibe distribución limitada entre una audiencia altamente especializada.

IDRC-MR252e
February 1990

OIL CROPS:
PROCEEDINGS OF THE THREE MEETINGS HELD AT PANTNAGAR AND HYDERABAD, INDIA, 4-17 JANUARY 1989

1. The Brassica Subnetwork-II
2. The Other Oil Crops Subnetwork-I
3. The Oil Crops Network Steering Committee-I

Edited by

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Organized by

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FOREWORD

The proceedings of the various oilcrops sub-network meetings which are published in this volume come at an important time for the oilseeds industry in India. The Technology Mission on Oilseeds which has recently been established by the Government of India is charged with making the country self-sufficient in oilseeds. There appears little doubt that this ambitious objective will be achieved within a short period of time by the dynamic process of collaboration between the outstanding group of scientists, administrators, businessmen, and many farmers who are involved in the task. Experience from the Indian Green Revolution, perhaps one of the world's most outstanding achievements in recent years, when cereal production was more than doubled within a few years, will enable Indian scientists and administrators to carry out a green revolution in oilseed production.

All of us who participated in the various sub-networks meetings and in the International Safflower Conference have benefited enormously from hearing about the Indian experience in increasing production of all these crops. The participants in the meetings have also agreed to play an increasing role in the organization and running of the various sub-networks. This should lead to the very satisfactory situation whereby the members run the networks according to their own needs, with full sharing of the available information, germplasm and resources. IDRC will continue to provide some limited resources towards network activities, and it is expected that other donors will also contribute.

I would like to thank the Government of India and all those who contributed so much to the success of these meetings for their excellent contributions, on behalf of all the participants.

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INTRODUCTION

The Oilcrops Network went into several phases in this one decade: 1981-90. The Network was established in 1981 by the International Development Research Centre (IDRC) to serve, advise, and coordinate the efforts of oilcrops scientists of the IDRC-supported projects in Eastern/Southern Africa and South Asia. In 1984, the network continued its efforts to strengthen the transfer of technology among all national oilseed programs in these regions. By 1987, a new strategy was adopted to decentralize the efforts by establishing four subnetworks under the umbrella of the Oilcrops Network:

1. Brassica Subnetwork - 1st meeting, 7-9 May 1987, Sweden.
   - 2nd meeting, 4-12 January 1989, India.
2. Sunflower Subnetwork - 1st meeting, 25-29 January 1988, Kenya.
3. Sesame Subnetwork - 1st meeting, 25-29 January 1988, Kenya.
4. Other Oilcrops Subnetwork - 1st meeting, 14-15 January 1989, India.

It was agreed that the committee members of each subnetwork are to meet every 18-24 months to discuss and endorse a working paper for the activities of the next period. The Steering Committee of the whole oilcrops network is to meet every year to discuss and approve the policy and recommendations of the four subnetworks.

The proceedings of the Brassica Subnetwork-1st meeting were published in December 1987 (IDRC-MR 168e). The proceedings of the Sunflower and Sesame Subnetworks-1st meeting were included in the Proceedings of the Fourth Oilcrops Network Workshop published in November 1988 (IDRC-MR205e).

This volume includes the proceedings of the second meeting of Brassica Subnetwork, and the first meeting of the Other Oilcrops Subnetwork. The volume also includes the first meeting of the Oilcrops Network Steering Committee held following the other meetings, 16-17 January, 1989.

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The Oilcrops Network acknowledges the continued support of IDRC without which these meetings could not have been possible, and these proceedings could not have been published.

The cooperation of the Indian Council of Agricultural Research, the G.B. Pant University of Agriculture and Technology, and the Directorate of Oilseeds Research is very highly appreciated. Special thanks are due to Dr. Basudeo Singh and Dr. V. Ranga Rao who acted as local coordinator, and helped to make these meetings a success.

The editor is particularly grateful to the previous and present staff of the Oilcrops Network in Ethiopia: Mrs. Martha Kebede and Mrs. Seada Ali for typing, and Mr. Seid Ahmed for Proof-reading. Thanks go also to Miss Meskerem H/Mariam and Miss Elizabeth Basliyos for their help in typing, and to Mr. Wossen Taye and Mr. Nigussie Alemayehu for their help in editing/proof-reading.

Abbas Omran
Coordinator/editor

Part 1.

Brassica Subnetwork-II

Pantnagar, India

4-12 January, 1989

OPENING REMARKS

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Distinguished scientists, Ladies and Gentlemen:

I consider it a proud privilege that the International Development Research Center of Canada has chosen Pantnagar to be the venue for the Second Brassica Sub-Network meeting of the Oilcrops Network for East African and South Asian Region and I have been called upon to give the opening remarks for this meeting. I feel happy to be among the distinguished Brassica scientists from East African, South Asian, European countries and Canada. This meeting acquires special significance as it is being held in India at such an important time when the country is faced with huge shortage of edible oil and has, therefore, launched a "Technology Mission on Oilseeds" and rapeseed-mustard has been given a special thrust for improved production and productivity under this mission in the state of Uttar Pradesh (U.P.) in which this University is located. The state of U.P. contributes maximum to the area and production of rapeseed-mustard crop which is next only to groundnut in terms of area and production of edible oil crops in India.

Under the Seventh Plan period (1984-85 to 1989-90), the area and production of rapeseed-mustard is to be increased from 3.98 million hectares and 3.03 million tons, in 1984-85 to 4.5 million hectares and 3.82 million tons respectively, in 1989-90. Similarly, the productivity of rapeseed-mustard during the same period is to be increased from 771 kg/ha to 890 kg/ha. This would be possible only when the crop production technology developed by the scientists is successfully transferred and adapted by the farmers. A number of transfer of technology programs are underway to achieve the maximum possible adoption of technology by the farmers. A special thrust is also underway to intensify the research efforts for the development of cheaper technology of crop production like pest and disease resistant varieties with maximum cost benefit ratio and quality improvement of the produce.

For India, rapeseed/mustard holds a greater promise for increase in area, production and productivity. It is being now extended and adapted by the farmers in non-traditional areas. Therefore, this crop deserves special attention. This was realized as early as mid-seventies and IDRC was invited to provide financial support to rapeseed/mustard research at Pantnagar and Hissar. IDRC's support for rapeseed/mustard research at Pantnagar became available from September 1979 which continued upto October, 1986, a record period of 7 years for an ad-hoc project. During this period, our oilseed scientists at Pantnagar developed the first two national varieties of mustard, Kranti and Krishna and the first national variety of Toria PT-303 which have 15-20% superiority in yield over traditional varieties and are very well and widely adapted by the farmers. A state variety of Toria (PT-30) was also developed during this period. Two strains of yellow sarson (PYS-6 and PYS-841) and one strain of Toria (PT - 507 - B) developed by the university scientists, have also been identified for pre-release multiplication and adaptive trials. The above varieties developed by Pantnagar oilseeds scientists contributed significantly to the increase in productivity of rapeseed-mustard from 573 kg/ha in 1982-83 (before the release of the above varieties) to 707 kg/ha in 1986-87.

During the operation of IDRC-supported project on rapeseed/mustard, it was realised that collaboration between leading rapeseed research centres in Canada and India in some specific areas of research would be very useful and would go a long way in increasing and stabilizing the rapeseed-mustard yield in India. Consequently, an idea of Indo-Canadian Cooperative Research Project on rapeseed/mustard was mooted for cooperation between the two countries in heterosis breeding of rapeseed/mustard, Alternaria and white rust resistance and quality breeding. The said project with IDRC financial assistance is to be launched shortly in which Pantnagar figures as a major centre from India. IDRC's initiative andsupport for this project is highly appreciated.

I am happy to note that IDRC has established a *Brassica* Sub-Network to bring the rapeseed scientists from East African and South Asian countries at a single platform and provide a forum to discuss their common problems, collaborate with each other in exchange of material, information and scientists and provide opportunity for training of the project personnel. The establishment of *Brassica* Sub-Network and its activities will go a long way in helping the collaborating countries to overcome major problems which limit the productivity of rapeseed-mustard and strengthen the research base for still higher production technology. Pantnagar shall always contribute its best for the success of the *Brassica* Sub-network activities.

With these remarks, I wish a grand success to the deliberations of the distinguished rapeseed scientists who have gathered here in bringing about quantitative change in *Brassica* research in concerned countries. I thank IDRC for its continued support to *Brassica* research. I also thank you once again for giving me an opportunity to be amongst you.

RECENT DEVELOPMENTS IN OILSEED BRASSICAS

R.K. Downey

It is a pleasure and honor for me to be invited to attend the second Brassica Oilseed Subnetwork Meeting. I am much indebted to IDRC for this opportunity and look forward to the discussions of the next two weeks.

In this short presentation I will deal with some of the more recent developments that have or are presently taking place that may be of interest to this group of Brassica scientists and then give a brief description of the objectives and plans for action in the India/Canada Brassica Oilseed Co-operative Improvement Project to be initiated early in 1989. However, I will leave the discussion of the disease portion of that program to my colleague, Dr. P.R. Verma, who is on a transfer of work from the Agriculture Canada Research Station, Saskatoon, to India and G.B./ Pant University.

The importance of Brassica oil as a source of edible vegetable oil continues to expand. Indeed production data recorded by the publication, Oil World, indicates that the world production of Brassica oil during the period 1982 to 1987 has grown faster than any vegetable oil, including palm (Table 1). Canada was expected to add significantly to that growth in that a record 8.96 million acres were sown in 1988. Unfortunately, due to extreme heat and drought, the average yield of the 1988 crop was reduced by 18 to 20%, resulting in a total seed production unchanged from the previous year.

Table 1. World vegetable oil production as percent of the 10 major oil crops and percent change 1982/83 through 1987/88.

Vegetable Oil	Production Year				% change 82/3-87/8
	82/83	84/85	86/87	87/88	
Soybean	30.4	27.5	27.8	26.5	9
Palm	12.1	13.1	14.1	14.2	48
Rapeseed	10.8	11.6	13.1	13.2	53
Sunflower	13.0	13.0	12.8	12.9	25
Cotton	6.7	7.8	5.7	5.9	10
Groundnut	6.1	6.2	6.0	5.1	5
Total 10	------------- Millions of tones ------------				
Major oils	46.1	49.8	55.2	58.0	26

Source: Oil World

One of the areas of considerable interest is the development of hybrid varieties. The Chinese scientists are probably further advanced than other countries in utilizing a cytoplasmic male sterile (CMS) genic restorer system in *B. napus* although it is my understanding that all hybrid varieties now in production are of rapeseed rather than canola quality. In Canada, several *B. napus* hybrids, based on the Chinese "Polima" CMS system, have been in official trials for the past three years. Results have not been up to earlier expectations. Seed yields have only been 5 - 10% above the better open pollinated cultivars and the oil content has been one or more percent below the check. There is good evidence to indicate the Polima cytoplasm, when introduced to Canadian and European spring *B. napus* parents, significantly reduces the expected level of heterosis, based on hand crosses between the same parents before the Polima cytoplasm was introduced. It is anticipated that with further breeding, parents that are more compatible with the Polima cytoplasm will be developed.

An additional complication has been the difficulty in obtaining a good seed set on female rows in the certified seed production fields. The use of honey bees has not been fully effective, while leaf cutter bees, although more effective, significantly add to seed production costs. Apparently such problems have not been experienced in Australia or Europe where experimental work on hybrids is also on-going.

In addition to CMS hybrids, some *B. napus* hybrids based on the introduction of self incompatible (SI) genes (S alleles) from *B. oleracea* have also been developed and are in official trials. These hybrids appear promising; however, the ease and economics of parental seed production is still under investigation. At Saskatoon, Dr. D. Hutcheson has also been introducing Dr. Hinata's CMS-genic restorer system, based on *Diplotaxis muralis* cytoplasm from the vegetable form, into the oilseed form of *B. campestris*. However, it is too early to tell what level of heterosis will result from crosses between canola quality parents.

Other CMS systems are under intensive investigations in other programs around the globe such as the Mockpo system in Korea, the Ogura system in France and other European countries, and the nigra-based system in India.

Work toward further modifications of the fatty acid composition of Brassica oil is continuing but the desirability or need for additional changes to the present canola oil composition is now questioned by the nutritionists. Indeed, in 1987 canola oil received the Food Product of the Year Award from the American Heart Foundation of New York based on its very low content of saturated fatty acids and its moderate level of alpha linolenic acid (Table 2). Nevertheless, Stellar, a low (<3%) linolenic cultivar developed by Dr. B.Stefansson at the University of Manitoba, is undergoing commercial evaluation (Table 2), and several programs are underway to increase the erucic acid to more than 50% and oleic to 80%. Swedish breeders have also developed a high palmitic acid strain of *B. campestris* (Table 2) that would have an advantage for the manufacture of 100% canola margarines.

In the measurement of glucosinolates the newest method proposed is based on X-ray defraction of sulphur in the seed sample (1). The method will readily distinguish between high and low glucosinolate seed, but the high cost of the instrument and the fact that it does not lend itself to batch mode operations would limit its application to many breeding programs. However, the EEC may adopt this type of measurement to distinguish which commercial seed lots will be eligible for support payments when the double low requirement comes into force for the 1991 harvest. It should also be noted that the EEC will measure the total glucosinolates present, including indole glucosinolates, and report umoles of glucisinolates present on a whole seed basis. This differs from the Canadian practice of measuring the aliphatic glucosinolates and reporting them on the basis of umoles per gram of oil-free meal.

Table 2. Fatty acid composition of normal and modified canola oil resulting from selection.

Oil type and variety	Fatty acid composition %							
	16:0	6:1	18:0	18:1	18:2	18:3	20:1	22:1
Canola (Westar)[1]	4	<1	2	62	20	9	2	<1
Low 18:3 (Stellar)[2]	5	<1	2	64	24	<3	1	<1
Hi 18:2, Low 18:3[1]	5	<1	2	55	29	7	1	<1
Hi 18:2, Low 18:3[1]	5	<1	2	57	28	6	1	<1
Hi Palmitic sel[n3]	10	4	1	51	19	13	1	<1

[1] Rakow *et al.*, 1988 (average of 3 years of field trials).

[2] Steffansson (personal communication).

[3] Persson, 1985.

I would like to take this opportunity to set straight the information on the glucosinolates that are present in the standard cultivars of Toria, Sarson (*B. campestris*) and Rai (*B. juncea*) grown in the Indian subcontinent. It has been reported (2) that *B. juncea* from the Indian subcontinent contained glucosinolates that yielded either butenyl or both butenyl and allyl isothiocyanates. Reports show that certain areas in India and Bangladesh prefer the pungent oil of *B. juncea* to that of Toria and the fact that when Bangladesh purchases mustard seed from Canada, for domestic edible oil use, they specify maximum allyl isothiocyanate levels tended to suggest that the use of allyl isothiocyanate-yielding cultivars was widespread. However, recently we had an opportunity to analyze a number of *B. juncea* seed samples from Bangladesh. All contained glucosinolates that give rise to only butenyl isothiocyanate. This led to the analysis of seed of varieties grown in India and Pakistan. Butenyl-producing glucosinolates were dominant in all samples. Thus it is probable that the seed samples analyzed by Vaughan and Gordon (2) resulted from outcrossing or admixtures with European or Chinese high allyl strains and cultivars. It should also be noted that in all the Toria and Yellow and Brown Sarson cultivars analyzed to date butenyl isothiocyanate has been the dominant glucosinolate breakdown product, with other aliphatic glucosinolates being absent or present in only trace amounts.

One of the primary objectives of the Saskatoon and other oilseed Brassica programs has been to develop a canola quality *B. juncea*. Under Western Canadian conditions, *B. juncea* has shown higher seed yields, greater drought and heat tolerance and resistance to blackleg and pod shattering. Since low erucic acid and high oil strains are now available in *B. juncea*, the barrier to achieving this goal has been the absence of the low glucosinolate characteristic. Fortunately, through the excellent work of Drs. H.Love and G. Rakow at our Research Station in Saskatoon, a low glucosinolate *B. juncea* strain has been developed. The strain has now been grown at four locations over two years and the glucosinolate level of these increase plots has ranged from 4 to 8 umoles/g of oil free meal, well within the canola range. Although a great deal of work remains to be done before an adapted high yielding canola *B. juncea* cultivar can be developed, the breeding of the low glucosinolate strain is a major breakthrough, not only for Canada but also the Indian subcontinent where *B. juncea* is the major *Brassica* oil crop species.

Many forms of biotechnology are being successfully applied to the *Brassica* oilseed crops. This past growing season the Saskatoon Research Station, in co-operation with Monsanto, tested plants of the Westar cultivar *(B. napus)* that had been transformed with a gene imparting resistance to the herbicide Roundup (glyphosate). Although the transformed plants were resistant to the herbicide, the level of resistance was not sufficient for commercialization. Further modification of the gene will be required to increase the level of resistance. This was the first field trial of transformed plant material in Canada.

Other herbicide resistant genes have or will soon be placed in Brassica oilseed plants, including the ALS gene for resistance to sulfoneturon methyl and a gene that imparts resistance to glufosinate ammonium (Basta).

Finally, we should briefly consider the Agriculture Canada/India Rapeseed/Mustard Improvement Program sponsored by IDRC. The overall objective is to improve the product quality and productivity of rapeseed and mustard in India through increased yield potential, enhanced yield stability and improved oil and meal quality. The four specific goals by which the objective will be achieved are:

a) reduce the incidence of Alternaria disease in the oilseed Brassicas in India;
b) reduce the incidence of whiterust disease in the oilseed Brassicas;

c) develop improved cultivars of mustard *(B. juncea)* possessing heterosis for higher seed and oil yield; and

d) develop improved cultivars of rapeseed *(B. campestris)* possessing heterosis for higher seed and oil yield.

Specific steps to achieve these goals have been agreed upon.

The program will involve six universities/institutions in India and three collaborating institutions in Canada (Table 3). Training in Canada of 3 - 4 months duration will be provided for certain scientists from all participating Indian institutions, and two Canadian pathologists will undertake transfers of work to India during the life of the project.

This project is expected to result in varieties of rapeseed and mustard available to the farmers which have higher and more stable yields and better returns. The improved oil quality will result in improved utilization in the diet, while improved meal quality will provide a higher quality non-toxic livestock feed. Increased rural processing will result from an increase in oilseed production. The consumer as well as the farmer will benefit from improved availability of oil, while the Indian economy will benefit by reducing a major drain on her hard currency resources.

Table 3. Scientific attachments and Canadian training (3-4 months)

Objective	Year	Discipline	From	To
Alternaria	1	Pathology	Pantnagar	Alberta
	2	Pathology	Rajendra	Alberta
	2	Breeding	Rajendra	Alberta
White Rust	1	Pathology	Morena	Saskatoon
	2	Breeding	Pantnagar	Saskatoon
	2	Pathology	Morena	Winnipeg
	3	Breeding	Morena	Winnipeg
Heterosis in *B. juncea*	3	Breeding	IARI Delhi	Saskatoon
Heterosis in *B. campestris*	2	Breeding	Pantnagar	Saskatoon
Oil & Meal quality	2	Breeding	Faizabad	Saskatoon
	2	Biochem.	Faizabad	Saskatoon
	3	Biochem.	Pantnagar	Saskatoon

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THE INTERINSTITUTIONAL COLLABORATIVE RESEARCH PROGRAM ON WHITE RUST (*ALBUGO CANDIDA*) BETWEEN INDIA (ICAR) AND CANADA (IDRC) FOR RAPESEED-MUSTARD IMPROVEMENT

P.R. Verma

Under the collaborative research program on white rust (*Albugo candida*) between Canada (IDRC) and India (ICAR) for rapeseed-mustard improvement, the research reported here was conducted during the six month period while I was in India mainly at the G.B. Pant University of Agriculture and Technology, Pantnagar; Oilseeds Plant Pathologist and Plant Breeders at Regional Research Station, Morena, were also involved in research and training.

Objectives: The main objectives of the visit to the participating institutes in India were as follows:

1. Collection of stagheads from different *Brassica* crops.

A detailed survey of several mustard growing areas (districts) in M.P. and Rajasthan was carried out in 1988, and also to a limited extent in 1989. Stagheads from several fields of *Brassica juncea*, *B. campestris* var. Toria, *B. campestris* var. Yellow Sarson, *B. tornefortii* and *Eruca sativa* were collected. Staghead material has been air-dried, crushed and is being stored in refrigerator at 7-8^{0}C, both at G.B. Pant University, Pantnagar, and Saskatoon Research Station. The material will be used for germination of oospores for laboratory and field inoculation studies and for identification of biological races of *A. candida*.

2. Development of methods/ techniques.

The methods described here were developed by me at the Saskatoon Research Station and have already been reported in several scientific publications. These methods are essential for: i) determining conditions essential for production, survival and germination of sporangia and oospores; ii) initiation of disease in the laboratory, growth chamber, greenhouse, and field; iii) screening *Brassica* germplasm against *A. candida* and inheritance of resistance; iv) identification of biological races of *A. candida*, and v) determining effect of different environmental factors on progression of white rust.

These methods require specific temperature, humidity and lighting conditions and are already being used at the Saskatoon Research Station for several years. The main purpose of my visit to the participating institutes in India was to see if these methods could be made to work under less environment - controlled conditions in India.

a). Method for germination of sporangia

To obtain a suspension of sporangia, newly ruptured sori from infected leaves were gently dislodged with an artist's soft brush, a stainless steel spatula, or a razor blade, and allowed to fall into a petri plate containing sterilized distilled water. Using a small glass rod, the contents of the petri plate were gently stirred to disperse the sporangia. Plates were incubated at 10-12^{0}C in the refrigerator for 1-2 hours. During winter months (November-February), sporangia also germinated successfully even at room temperatures ranging from 16-19^{0}C.

Germination of sporangia (production of zoospores) was determined by examining sporangial suspension in petri plate under microspore. Plant Pathologists both at Pantnagar and Morena are now using this method successfully.

Suggestions:

- i) Sporangia do not germinate in sterilized or unsterilized Pantnagar tap water.
- ii) Unsterilized distilled water will also induce germination.
- iii) While examining sporangial suspension in Petri plates under microscopes (10X) for germination of sporangia, more zoospores will be visible at the bottom of the plate than on the liquid surface.
- iv) Avoid using sporangia from senesced infected leaves.
- v) Avoid getting dirt of leaf peelings while collecting sporangia from leaves.
- vi) Frozen sporangia on diseased leaves, or those in plastic vials will remain viable for 3-4 months.

b). Method for germination of oospores (resting spores)

Stagheads from several mustard fields in Rajasthan collected in March 1988 had been stored dry in the laboratory of Dr. J.S. Kolte, Department of Plant Pathology, Pantnagar. Hypertrophied tissue (staghead) was ground with a mortar and pestle, and the grindings were screened through a 60-mesh sieve to give a brown powder consisting largely of oospores of *Albugo candida*.

A small amount (0.3-0.5g) of oospore powder was placed in 50 ml sterilized distilled water in a 125 ml. Erlenmeyer flask (100-125 ml in 250 ml flask) and incubated at 150-200 rpm on a rotary shaker at 18-24°C for 9-12 days. The spore suspension was then poured into a petri dish and kept stationary for 24-48h in a refrigerator at 10-13°C. Spore suspension was examined under microscope for presence of zoospores.

Suggestions:

- i) Collect only dried or almost-dried stagheads from fields. A large proportion of oospores from green stagheads are immature (absent or poorly developed central globule) and will not germinate successfully.
- ii) Avoid collecting stagheads with downey mildew (*Peronospora parasitica*) mixed infection.
- iii) Avoid grinding stagheads which have been infested with mites, nematodes or any other organisms.
- iv) Oospores do not germinate in sterilized or unsterilized tap water from Pantnagar.
- v) While incubating on the rotary shaker, a ring of oospore powder deposited around the neck of the flask above the water line should be removed (once or twice a day) and mixed back in the suspension.
- vi) If possible, store air-dried stagheads in zero-degree room.

c). Detached-leaf culture technique for growing *A. candida*

In India, screening *Brassica* germplasm for resistance to *A. candida* has been restricted by a lack of controlled environment facilities. To overcome this problem, an attempt was made to determine if the detached-leaf culture technique, developed by me and used in several studies under controlled environmental conditions at Saskatoon Research Station, could also be used for *A. candida* infection studies at the Plant Pathology Department, G.B. Pant University of Agriculture and Technology, Pantnagar, where air temperature, relative humidity and lights are not precisely controlled. The room temperatures (15-21^{0}C) during the winter months (November-February) were found favourable for obtaining infection on detached leaves/cotyledons.

Healthy leaves or cotyledons from 12-14 days old seedlings were detached and transferred to petri dishes containing 20-25 ml autoclaved benzyladenine (1 ppm) agar (1%) medium. Leaves were placed in the dishes with their lower (abaxial) surface in contact with the medium within one hour of detachment; the upper (adaxial) surface was inoculated. Four to five leaves were placed in a plate. Leaves were drop-inoculated (2-4 drops per leaf) with a zoospore suspension derived either from germinating sporangia or oospores. Control leaves were treated with distilled water. Petri dishes placed in a tray full of water were incubated in a room with a day-night temperatures of about 22-14^{0}C, respectively. Leaves were maintained under a 12 h day (lux not measured) and a mister (very coarse) was used 3-4 times a day during the first four days of the experiment. Observation on percent infected leaves were recorded 10-15 days after inoculation. A leaf with one or more visible pustules was considered as infected. Several tests were carried out using leaves/cotyledons of *B. juncea, B. campestris* var. Toria, *B. napus, B. nigra, B. carinata, Sinapis alba, Raphanus sativus, Eruca sativa, Sisymbrium officinale*, and *Capsella bursa-pastoris.* Inoculum from only *B. Campestris* var. Toria and *B. juncea* were used in all cross inoculation experiments. Inoculum from *B. campestris* var. Toria produced pustules only on B. campestris leaves; similarly, inoculum from *B. juncea* produced pustules only on *B. juncea*. Number of pustules per infected leaf and also size of pustules were considerably lower than in experiments conducted at Saskatoon Research Station under controlled environment conditions.

Suggestions:

i) To reduce contamination, detach leaves/cotyledons from plants grown in glasshouse.

ii) For obtaining large, thick cotyledons, remove apical meristems of glasshouse-grown plants every 3-4 days.

iii) On benzyladenine-agar medium, older leaves tend to senesce faster than younger leaves.

d). Inoculation technique for screening *Brassica* germplasm for resistance against *A.candida*

Using *B. juncea*, and *B. campestris* var. Toria as hosts, several inoculation experiments were carried out in the glasshouse and outside on plants grown in 12-15 cm diameter pots (4-5 plants/ pot). Only inoculum from *B. juncea* and/or *B. campestris* var. Toria were used in all inoculation experiments. Using a plastic bottle sprayer, 3-4 week old plants were inoculated with a zoospore suspension derived from germinating sporangia. Control plants were treated with distilled water. Pots were incubated over a cement pit (approximately 3'L X 2'W X 2' Deep) full of water under an angle iron misting chamber for 3-4 days. Plants were sprayed with distilled water once or twice a day for five days. Observation on percent infected plants were recorded 12-14 days after inoculation. Only *B. juncea* plants inoculated with *B. juncea* inoculum, and *B. campestris* plants inoculated with *B. campestris* var. Toria inoculum showed infection. Oilseeds Plant Pathologists are now using this method successfully for screening *Brassica* germplasm for resistance against *A. candida*.

Suggestions:

- i) Grow only 4-5 plants per 12-15 cm pot.
- ii) After germination of seeds in the glasshouse, transfer pots outside in order to get good sturdy plants; because of poor lights in the galsshouse, plants become very spindly and etioliated.
- iii) In order to grow good plants in pots, Pantnagar soil should be mixed with farm yard manure and sand.
- iv) Place pots in a metal tray and flood trays to water plants.

3. Establish disease nursery in the field

For screening *B. juncea* introductions in the field, a disease nursery has been established both at Pantnagar and Morena. In order to build up the inoculum in this particular patch of land, plant pathologists have been advised to add every year a large amount of ground, sieved staghead powder (oospores) along with the seed. Only stagheads collected from *B. juncea* plants are to be added. High soil moisture needs to be maintained for germination of oospores and early infection. The overhead sprinkler irrigation system proposed both for Pantnagar and Morena will be for this disease nursery.

At Morena Research Station, the incidence and severity of white rust was significantly higher on *B. juncea* plants grown in the oospore-added disease nursery than anywhere else at the farm. Also, the plants in the disease nursery were the first one to show white rust symptoms. The plant pathologist and plant breeders were very much pleased with this success.

At Pantnagar, the incidence and severity of white rust on plants in the disease nursery was similar to those grown in areas without oospores. The most probable reason was that the nursery did not get irrigation until one month after seeding.

4. Determine if oospores are also produced in infected leaves

In 1983, we reported for the first time that the production of *A. candida* oospores in detached naturally infected *B. campestris* leaves after inoculation and 14 days of incubation at temperatures of 9-24°C; higher temperatures were more favourable for oospore production.

At Pantnagar, white rust infected, senesced leaves of both *B. juncea* and *B. campestris* var. Toria were examined late in the season, and were found to contain a large number of mature oospores. This is the first report of the production of *A. candida* oospores in naturally infected leaves.

Until now, it has been assumed that in rapeseed and mustard *A. candida* produced oospores mainly in hypertrophied inflorescences (stagheads) and to a smaller extent, in stem blisters. In light of our 1983, and this finding, we now know that the naturally-infected *Brassica* leaves are also important for adding oospores, the primary source of infection, in the soil.

5. Identification of biological races of *Albugo candida* on different *Brassica* crops in India.

Amongst the several fungal diseases affecting oilseed crops in India, white rust caused by *Albugo candida* is considered most destructive. Although, a large number of accessions in the genus *Brassica* and its allies have/are being evaluated since 1979, the progress in finding sources of resistance against *A. candida* has been rather less than satisfactory.

The progress in breeding for resistance against white rust hinges mainly in identifying biological races of *A. candida* affecting various *Brassica* crops. At present, eight biological races of *A. candida* have been reported from North America. To our knowledge, presently, there is no information regarding biological races of *A. candida* on various *Brassica* crops in India.

Seeds of various known differential hosts of reported biological races were taken from my lab. at the Saskatoon Research Station to G.B. Pant University of Agriculture and Technology, Pantnagar, India, for cross-inoculation studies to be carried out for identification of biological races of the white rust fungus, *A. candida*. Following is the list of seeds taken to India:

1. *Raphanus sativus* (radish) cv. Comet
2. *R. sativus* (radish) cv. Cherry Belle
3. *Brassica juncea* cv. Domo
4. *B. juncea* cv. Commercial Brown
5. *B. juncea cv.* Southern Giant Curled
6. *B. campestris* cv. Torch
7. *B. campestris* cv. Candle
8. *B. campestris* cv. Tobin (1986 Re-Sel, Seidel)
9. *B. campestris* cv. Tobin 1
10. *B. campestris* cv. Tobin 2
11. *B. campestris* cv. Tobin 3
12. *B. napus* cv. Regent
13. *Sinapis alba* cv. Gisilba
14. *Capsella bursa-pastoris*
15. *Sisymbrium officinale*
16. *Roripa islandica*

Results of several preliminary inoculation studies, both on detached leaves in the laboratory and on intact plants in pots in the glasshouse, suggest that in India, the race of *A. candida* attacking *B. juncea* is different from the race attacking *B. campestris* var. Toria. This appears to be similar to what has been reported from North America. This, however, needs to be confirmed with more detailed experiments involving differential hosts. Also, need to be determined are the races attacking *B. nigra, B. carinata, B. torrnefortii, B. campestris* var. Yellow sarson, *Eruca sativa* (taramira) and other Cruciferae hosts grown in India.

The reason I was not able to conduct detailed experiments for identification of biological races using various differential hosts was lack of time, and equipments including defreeze, humidifiers, light and temperature controlled incubating room.

Having worked out the methods for gemination of sporangia, and oospores, detach-leaf culture technique, and inoculation method in the glasshouse, I can probably complete identification of biological races of *A. candida* infecting various Cruciferae crops in India in four months (November-February) provided the equipments mentioned above are in place at Pantnagar.

STABILITY PARAMETERS FOR SEED CHARACTERS IN DIFFERENT SPECIES OF OLEIFEROUS BRASSICA[1]

H. Singh,[2] D. Singh,[2] and V.S. Lather[2]

Abstract

Stability analysis of 32 genotypes of seven oleiferous Brassica species revealed that the dates of sowing environments differ significantly from each other and these genotypes had considerable variability for seed characters. Based on stability parameters, *B. napus* genotype viz., RC1433 for seeds per siliqua, EC129126 and Gulivar for percent oil content and Midas for seed yield were the stable genotypes. In other species BC_2 (*B. carinata*) and Varuna (*B. juncea*) were identified as the ideal genotypes based on their stability parameters for oil content and seed yield, respectively.

Understanding of stability parameters for developing the stable genotypes in crop plants in a priori consideration in crop improvement program. In oleiferous *Brassica* grown under wide range of environmental conditions for commercial cultivation, such information is limited which otherwise warrant immediate attention as the production and productivity of these crops fluctuate over years. The present study was aimed at identifying stable genotype for desirable characters from important *Brassica* species.

Materials And Methods

The material for the present study comprised of 32 genotypes of seven *Brassica* species. The experiment was conducted in randomized block design with two replications under early, normal and late sown conditions of 1982-1983 and 1983-84 winter seasons, at Haryana Agricultural University, Hisar, India. The sowing dates were split at 20 days interval from first week of October to middle of November during both years. Each entry was represented by 5 rows of 6m length. Row to row and plant to plant distances within row were kept at 30 cm and 15 cm, respectively. Loam soil of the experimental area was applied with 80 kg Nitrogen per hectare as a basal dose and it was irrigated twice (pre-sowing and at flower initiation). The seed characters viz., seeds per siliqua, 1000-seed weight (g), oil content (%) and seed yield (g) were recorded on 10 competitive plants in each entry. The percent oil content was determined by NMR. The data was analyzed and interpreted according to (1).

Results And Discussion

Pooled analysis of variance revealed the presence of genetic variability in the material under investigation, Table 1.

Significant mean square due to environment (linear) indicated differences between environments and their considerable influence on seed characters. Magnitude of environment (linear) was higher which envisaged the reliability of prediction (2). Significant pooled deviation for these characters indicated that the genotype differ considerably with respect to stability. The values of mean $(\bar{x})$,

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[1] Received but not presented.

[2] Department of Plant Breeding, Haryana Agricultural University, Hisar 125004, India.

Table 1. Mean squares from pooled analysis for seed characters in different species of oleiferous *Brassica*

Source of variation	d.f.	Mean squares			
		Number of Seeds/siliqua	1000 seed (g)	Seed Yield per plant (g)	Oil content (%)
Varieties (v)	31	54.71*	3.31*	42.95*	61.26*
Environment (E) + (V x E)	160	4.31*	0.26*	31.61*	8.21*
E linear	1	148.89*	15.19*	2388.57*	633.37*
V x E linear	31	5.87*	0.27*	18.19*	12.04*
Pooled deviation	128	2.80*	0.15*	16.44*	2.41*
Pooled error	186	2.11	0.003	3.14	0.66

*Significant at $p = 0.05$.

regression coefficient (b) on environmental index and deviation index and deviation mean squares from regression for seed characters are presented in Table 2.

In general, more number of seeds per siliqua was observed in *B. napus* genotypes followed by *B. campestris*. Sangam, T-9, BSH-1, Torch and Candle genotypes of *B. campestris* were stable for number of seeds per siliqua. Among *B. napus* genotypes, N-20 and RC 1433 were stable. RH7513, RH30, Blaze, RIK 78-6, Domo, Varuna and Phari Rai were stable from *B.juncea* group.

The genotypes of *B.alba*, *B. carinata* and *B. tournifortii* were also stable for number of seeds per siliqua. Taking all the three stability parameters in to consideration, RC1433 a *B. napus* genotype was found as an ideal genotype among all the genotypes of the seven *Brassica* species for number of seeds per siliqua.

Stability parameters for 1000 seed weight (g) revealed that none of the genotypes was stable. The variety of *B. juncea*, RH30, had high mean and above average response for 1000 seed weight.

Gullivar, EC129126, Prakash, BC_1, BC_2 and *B. tournifortii* were the stable genotypes for oil content. Gullivar, EC129126 and BC_2 had high mean, average response and a small deviation from linear regression. These were the ideal genotypes for their oil content.

In general, the low yielding genotypes Sangam, YSPB-24, Span, Torch, H715, Tower, EC129126, Domo and *B. alba* were stable for seed yield per plant. However, simultaneous consideration of high mean, regression coefficient unity and less deviation from regression for individual genotypes indicated Midas and Varuna to be the ideal genotypes. These two genotypes could be grown profitably over a large span of sowing time which is desirable in rapeseed and mustard growing regions of the country. These can also be considered as valuable material for their further yield improvement and for the transfer of their stability characteristics to other genotypes of respective species.

Acknowledgements

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Table 2. Estimates of stability parameters of different *Brassica* genotypes for seed characters

Sr. Genotypes	Number of seeds per siliqua			1000 seed weight (g)			Oil content (%)			Seed yield (g)/plant		
	Mean	b	sd^{-2}	Mean	b	sd^{-2}	Mean	b	sd^{-2}	Mean	b	sd^{-2}
B. campestris:												
1. "Sangam"	15.92	1.17	1.17	2.60	1.31	0.07*	44.57	0.65	1.87*	8.67	1.37	3.94*
2. R-9	14.66	1.84	0.26	2.75	0.90	0.05*	44.80	1.01	2.71*	9.72	1.16	10.44*
3. BSH-1	16.42	0-62	1.23	2.91	2.78	0.44*	45.80	1.35	1.52*	8.13	0.89	9.08*
4. YSPB-24	16.75	0.67	6.83*	3.03	1.77	0.19*	44.56	1.72	1.19*	6.82	0.67	4.84
5. Span	15.91	-0.54	4.85*	1.97	1.11	0.08*	42.84	1.62	5.08*	9.80	1.11	1.88
6. Torch	14.76	0.16	1.44	1.96	1.26	0.05	43.41	0.90	2.10*	8.65	0.96	0.61
7. Canoli	15.71	0.39	2.55*	2.00	1.16	0.06*	43.55	0.89	0.91*	10.31	1.39	7.59*
8. Candle	15.63	1.05	1.91	2.16	0.96	0.03*	43.99	1.66	1.19*	14.42	2.11	44.86*
9. Bele	17.55	3.02	2.69*	2.63	1.08	0.13*	44.70	1.44	1.34*	8.69	0.91	17.72*
B. napus:												
10. H. 715	16.57	2.61	3.00*	2.33	1.58	0.05*	43.42	1.97	1.23*	9.52	1.26	5.52
11. H1110	17.32	1.19	8.32*	2.47	0.38	0.20*	42.57	1.64	1.95*	17.98	2.41	54.68*
12. Tower	17.83	4.15	5.50*	2.87	0.23	0.03*	42.99	1.23	1.09*	9.02	1.01	-0.18
13. Regent	18.09	-0.58	3.23*	2.60	1.47	0.10*	42.62	1.08	0.79*	8.28	0.85	9.50*
14. Gullivar	15.29	1.78	3.36*	2.53	0.15	0.05*	42.82	1.35	-0.03	7.52	0.83	10.29*
15. Midas	19.15	1.34	3.29*	2.50	1.99	0.06*	43.78	2.00	3.37*	10.10	1.54	4.30
16. EC 129126	17.53	2.95	3.26*	2.00	0.05	0.05*	43.00	1.82	0.05	8.93	0.97	2.01
17. Norin 20	16.88	2.44	-0.22	2.55	0.86	0.22*	41.84	0.30	1.67*	8.59	0.64	19.77*
18. RC 1433	18.43	0.80	-0.67	2.23	0.58	0.03*	42.76	0.81	1.26*	7.52	1.07	19.55*
B. juncea:												
19. RH 7513	12.45	0.80	-0.93	2.85	1.42	0.07*	40.24	-0.55	1.16*	12.33	1.46	15.72*
20. RH30	12.92	-0.26	-0.51	4.35	4.35	0.08	41.54	0.28	1.49*	11.16	0.57	12.01*
21. Prakash	13.18	-0.15	2.16	2.47	0.81	0.01*	42.21	0.16	0.06	8.92	0.37	32.63*
22. Blaze	11.72	0.77	-0.18	2.10	0.54	0.02*	35.73	1.09	5.66*	12.02	0.51	26.32*
23. RIK 78-6-1	10.93	0.46	1.90	2.95	0.32	0.31	40.04	0.63	3.67*	10.96	0.67	10.42*
24. Domo	11.16	1.47	0.84	1.87	0.35	0.13*	40.46	1.40	0.90*	7.76	0.15	4.34*
25. Varuna	13.57	0.69	-0.65	3.80	1.56	0.23*	41.05	0.29	4.34*	11.27	1.18	4.69
26. Pahari Rai	12.35	1.09	-0.82	1.76	0.62	0.08*	40.62	-0.27	0.25	15.00	0.88	17.16*
27. Leth-Bridge-22A	12.38	0.82	-0.82	2.10	0.13	0.05*	39.27	0.75	0.79*	11.89	1.37	24.57*
28. *B.Chinensis*	6.30	1.60	2.28*	2.27	1.65	0.03*	44.28	-0.13	0.68	10.62	1.49	48.95*
29. *B.alba*	3.97	0.74	-0.70	5.34	0.21	0.11*	33.75	0.32	0.94*	5.85	0.57	-1.06
30. *B. Carinata*	12.06	0.15	0.90	3.30	0.68	0.16*	42.85	0.54	0.001	15.20	0.25	46.24*
31. *B. Carinata 2*	14.04	-0.21	-0.99	3.12	0.04	0.28*	41.28	1.07	0.25	10.66	0.53	-0.61
32. *B. tournifortii*	13.15	0.002	0.47	2.21	1.18	0.11*	31.55	0.41	0.05	7.33	0.75	7.03*

* Significance at $p = 0.05$.

OILSEED BRASSICA RESEARCH IN INDIA

P.R. Kumar

Among the oilseed crops grown in India, oilseed Brassica, collectively referred to as rapeseed-mustard, comes next to groundnut in importance. It is the most important winter oilseed crop of the country constituting the cultivation of the following eight species:

1. *Brassica juncea* ... Indian mustard
2. (i) *Brassica campestris* var. *Toria* ... Indian rape
   (ii) *Brassica campestris* var. *Dichotoma* ... Brown sarson
   (iii) *Brassica campestris* var. *Sarson*... Yellow sarson
3. *Eruca sativa*... Taramira
4. *Brassica napus*... Gobhi sarson
5. *Brassica nigra*... Black mustard
6. *Brassica tournefortii*... Wild mustard
7. *Brassica carinata*... Karan rai
8. *Brassica hirta/Sinapis alba*... White mustard

Production Trends

During the last three and a half decades there has been substantial increase in production and productivity of rapeseed-mustard in the country. The area which was 1.95 million hectares in 1949-50 has increased to 4.51 million hectares in 1987-88. Likewise, the production and productivity have increased from 0.81 million tones and 417 kg/ha in 1949-50 to 3.37 million tones and 747 kg/ha in 1987-88, respectively.

During 1988-89, the production is estimated to attain a new peak of more than 4.0 million tons.

Major Constraints

The cultivated species of the genus *Brassica* are highly prone to the attack by insect-pests and diseases. Aphid is the most serious insect-pest which causes heavy damage (35 - 73%) to the crop. This is followed by diseases like Alternaria blight, white rust and downy mildew which collectively cause yield losses ranging from 10 to 70%. Frost is another menace which takes a heavy toll of the crop. Although it is not a regular phenomenon, in a frosty year which occurs unpredictably, the extent of damage is more than 90%. In certain situations a parasitic weed, Orobanche, causes considerable damage to the crop. Nearly 53% of the area under rapeseed-mustard is grown under rainfed conditions. It is largely in the domain of small and marginal farmers. More than 60% of the area of the crop is grown as a mixed crop, mostly with wheat. Mustard receives little attention in terms of maintenance of plant population per unit area, crop management and crop protection because of the major emphasis of farmers on wheat. Cumulative effect of all these factors results in lower average yield of rapeseed-mustard.

Crop Improvement

Rapeseed-mustard group of crops has a wide spectrum of mating systems ranging from total cross pollination to total self pollination. The breeding methodology employed for the improvement, therefore, is different in different species/ types.

Introduction, mass selection, pure line selection, mass pedigree selection, back-cross method, recurrent selection, disruptive selection, diallel selective mating system, polycross method of developing synthetics, breeding composites, mutation and polyploidy method of breeding are the methods usually employed for improving the productivity of rapeseed-mustard group of crops.

Besides the development of high yielding varieties, efforts are being made to develop varieties possessing resistance/tolerance to biotic stresses like aphid and diseases and abiotic stresses like froal, drought, salinity/alkalinity and shattering.

(i) High yielding varieties

The development of varieties possessing high seed yield and high oil content have been the major objectives of breeding rapeseed/mustard using the above breeding methodologies. A good number of varieties of mustard, toria, brown sarson, yellow sarson and taramira have been developed which are released/recommended either by the State or by the Central Variety Release Sub-Committee. Prior to 1980, more than 10 varieties of toria, 6 varieties of yellow sarson, 11 varieties of mustard and 2 varieties of taramira were recommended for general cultivation. During 1981-88 period, as many as 18, 6 and 2 varieties of mustard, toria and yellow sarson, respectively, for irrigated areas and 8, 1 and 2 respectively for rainfed areas; have been recommended for different zones in the country, Table 1. The increased yields of recommended varieties under the multilocation testings ranged from 9 to 53% over standard checks under irrigated conditions. Under rainfed conditions, yield increases ranged between 9.92 to 31.26%.

Table 1. High yielding varieties of oilseed Brassica recommended during 1981-88.

Crop	Irrigated/ rainfed	No. of varieties	Average yield kg/ha (range)	increase over standard check (%)
Mustard	Irrigated	18	1950 - 1285	9.40 - 32.04
	Rainfed	8	1615 - 824	8.92 - 45.80
Toria	Irrigated	5	1125 - 573	9.32 - 31.80
	Rainfed	1	607	17.00
Yellow-sarson	Irrigated	2	1836 - 1236	23.33 - 53.00
	Rainfed	2	928 - 845	21.00 - 31.26
Toria* (TL-15)	Irrigated	1	1258	20.30

*Recommended for high altitude of Himachal Pradesh as a summer crop

(ii) Aphid resistance

Using T-6348 strain as a source for aphid resistance, extensive hybridization programs were taken up resulting in development of promising strains like TK-8501, RH-7846, RH-7847, CSR-1017 and Glossy B-85 identified as possessing high yielding ability as well as moderate resistance to mustard aphid. These strains are under the advance stage of testing.

(iii) Disease resistance

The resource genes in RC-781, YRT-3 and EC-126743 identified as resistant to Alternaria blight and white rust diseases were extensively utilized in hybridization program. A high yielding variety, RH-8113 of mustard possessing moderate resistance to Alternaria blight disease was recommended in 1985 for pre-release multiplication in

North-Western Zone which constitutes Punjab, Haryana, Rajasthan and Gujarat. In 1988, this particular variety was recommended by the Haryana State for general cultivation. Besides, a number of strains like PR-8701, PR-8705, KRV Tall and RH-8114 have been identified showing tolerant reaction against Alternaria blight disease.

(iv) Frost tolerance

Using the movable frost chamber, a good number of varieties of rapeseed-mustard have been identified as tolerant to frost injury. The most promising amongst them are the varieties RH-781 and RH-7361 of mustard. These varieties, besides showing frost tolerance, have been found to be high yielding. The variety RH-781 has already been recommended for Eastern Zone constituting Bihar, Orissa, West Bengal and Assam on account of its high yielding ability. In *B. campestris*, Canadian varieties, Span and Torch, are found to be frost tolerant.

(v) Drought tolerance

In *Brassica juncea*, a number of strains, CSR-814, CSR-975, CSR-212, CSR-838, CSR-257/RH-781, have been developed by selection which possessed tolerance to drought. In *B. campestris*, strains PT-30, PT-40 and PT-42 have been found to perform well under rainfed situations.

(vi) Salinity/Alkalinity tolerance

A variety NDR-8501 of *B. juncea* giving an average seed yield of 1333 kg/ha under irrigated conditions in the Central Zone (Uttar Pradesh and Madhya Pradesh) has also shown promise in saline soils. Besides, a number of strains have been identified to be promising in salt affected soils. These strains are NDR-8604, DIRA-344, DIRA-329, CS-209, DIRA-361, CSR-394, CSR-52, CS-12, CSR-50, BEC-199, BEC-218-218 and BEC-222. They are in advance stage of testing.

(vii) Shattering resistance

Efforts are also being made to develop shattering resistant lines. Some of the entries like RH-8130, RLC-1021, RH-8131, L-114-5-6-1, RH-30 and 1-117-5-6-2 are found to show moderate degree of resistance to shattering besides possessing high yielding ability. These entries are being evaluated in multilocation testing.

(viii) Breeding for other economic traits

Apart from these, strains/lines of *B. juncea* having a very bold seed size (9 g/1000 seed wt.), long pod, more number of seeds per siliqua, yellow seed coat, and high oil content have been developed and are under testing.

In *B. campestris*, apart from developing high yielding varieties, toria maturing in 70-85 days has been developed. Attempts are being made to develop varieties having bold seed size, multilocular siliqua in toria and brown sarson.

(ix) Development of varieties for late sown conditions

Attempts to develop suitable varieties of rapeseed-mustard for late sown conditions have resulted in identification of strain RH-7859 giving 1981 kg/ha compared to 936 kg/ha of Kranti in North Western Zone. In Central Zone, Pusa bold gave the maximum seed yield (793 kg/ha) as against 698 kg/ha of Kranti. A variety RLM-619 was found to give the maximum seed yield (606 kg/ha) compared to Varuna (466 kg/ha) in Eastern Zone.

(x) Rapeseed-mustard in non-traditional areas of Southern States

In an effort to improve the productivity of rapeseed-mustard in non-traditional areas, experiments with promising/elite strains of rapeseed-mustard were laid out in Maharashtra, Tamil Nadu, Andhra Pradesh and Karnataka States. In Maharashtra at Phaltan (on the basis of 3 years average) RLM-619 recorded the maximum seed yield (999 kg/ha) followed by 990 kg/ha and 989 kg/ha of Pusa Barani and RLM-514, respectively. Mustard trials were also conducted at 6 locations (Akola, Washim, Nagpur, Amgaon, Amravati, Buldhana) in Maharashtra during 1986-87 and 1987-88. On the basis of 12 locations average, Varuna was observed to record the highest seed yield (1324 kg/ha) as against 740 kg/ha and 680 kg/ha of Kranti and Krishna, respectively. In Tamil Nadu, on the basis of 9 locations average, B-85 (Seeta) exhibited the highest seed yield of 802 kg/ha compared to 491 kg/ha and 327 kg/ha of Kranti and Varuna, respectively. In Andhra Pradesh, a strain TM-21 attained the maximum seed yield (1452 kg/ha) compared to 1284 kg/ha of Kranti. Besides, Kranti was also sown at farmers' fields at 62 locations and an average seed yield of 985 kg/ha was recorded.

(xi) Introduction of rapeseed-mustard as a summer crop at high altitude

In an attempt to introduce rapeseed-mustard as a profitable summer crop at high altitude in hills and valleys, promising varieties were evaluated in Himachal Pradesh, Jammu and Kashmir. In H.P., toria variety TL-15 was found to be the most promising and was accordingly recommended in 1988 for pre-release multiplication. In Kashmir valley, mustard varieties KBS-150, Seeta and RH-30 are superior in performance in comparison to other improved varieties of mustard.

Production Technology

Improved cropping systems and other agronomic practices, both for rainfed as well as irrigated areas have been developed for different agro-climatic conditions of the country. Planting technique studies have conclusively established that pure crop of rapeseed-mustard is the most remunerative. Further, line sowing with recommended spacing, seed rate, fertilizer and thinning 15-21 days after sowing gives the best return. Mustard is predominantly grown as a mixed crop with wheat. The yield of mustard under such situation is usually poor. Cultivation of mustard intercropped with wheat in 1:9 ratio has given the highest net return. Likewise, growing mustard and gram in rows under rainfed conditions gives higher net return. Similarly, intercropping of toria/mustard in Autumn-planted sugarcane, intercropping mustard/yellow sarson in potato, and intercropping toria in gobhi sarson are more remunerative.

Transplanting of gobhi sarson gives more yield and economic returns than direct-seeded crop. It is likely to be a substitute for late sown poor yielding wheat. The advantage with transplanted crop is that it requires no thinning and has less weed problem.

In order to maintain the optimum plant population and to economize the use of seed and fertilizers, proto-type seed-cum-fertilizer drill (bullock drawn) and a manual seed drill have been fabricated. These are under advance stage of testing.

Rapeseed-mustard is responsive to Sulphur and boron application. Application of sulphur (20 kg/ha) along with born (1 kg/ha) gave more yield over control in deficient soils.

Weed control studies have established that pre-plant incorporation of Fluchloralin @1.25 litre/ha as well as pre-emergence application of Pendimethalin @1.25 kg/ha give an effective weed control and better crop yields. If the weed emerges late after planting, use of Isoproturon @0.75 kg/ha after 30 days of planting is recommended. These herbicides may be effectively used where manual weeding is not possible.

Studies on the optimum stage of harvesting of toria have shown that toria, if harvested at a stage when 75% of the pod turn yellow, can ensure timely sowing of wheat.

Studies on the effects of various technology package on seed yield of mustard and toria have demonstrated that an increase in seed yield ranging from 66.7 to 189.8% can be obtained by adoption of full technology package over the local practices in mustard under irrigated conditions. In toria, under rainfed conditions, the yield increase ranged between 118.2 to 198.9%. Amongst the individual factors of production, fertilizer application has been found to be more critical.

Extensive field demonstrations of rapeseed-mustard during 1987-88 indicated that seed yield ranged between 920 to 1357 kg/ha in Toria, 1250 to 1538 kg/ha in yellow sarson and 1214 to 3300 kg/ha in Indian mustard at various locations, Table 2.

Table 2. Field demonstration of rapeseed-mustard during 1987-88

State	No. of demonstrations	Seed yied (kg/ha)	
		Maximum	Minimum
Mustard			
Haryana	441	2344	1214
Punjab	3	1650	-
Gujarat	78	3300	1400
West Bengal	10	1544	-
Toria			
Assam	161	1357	920
Yellow Sarson			
West Bengal	7	1538	1250

Management of diseases

The major fungal diseases affecting rapeseed and mustard crops in India are Alternaria blight, white rust, downy mildew, powdery mildew and phyllody. Alternaria blight (*Alternaria brassicae*) characterized by brown or greyish spots on leaves, stems and pods is the most destructive and wide-spread disease. Compared to mustard, sarson is more prone to this disease. Moist and warm weather favours the disease. Spraying with Mancozeb-5 at intervals of 15 days, 40-45 days after sowing is recommended. This fungicide is cheap and helps in reducing the intensity of another important disease, i.e., white rust, which is characterised by white postules of *Albugo candida* on the lower surface of the leaves in the early stage, i.e., when plants are 45-50 days old. Later, the malformation of the floral parts takes place, which is known as stag-head formation stage. Apron 0.2% as seed dresser along with three sprays of Dithane M-45 @0.2% is recommended for reducing white rust and simultaneous occurrence of downy mildew (*Peronospora parasitica*) incidence at seedling stage. Sprays of Dithane M-45 or Zineb also helps in minimizing the severity of all the above three diseases on leaves and pods. If Apron is not available, spray of Dithane M-45 should be continued.

When there is attack of powdery mildew (*Ersyiphe cruciferarum*) which is characterised by white powdery mass on stem and leaves at later stages of plant growth, spraying with Wettable Sulphur (0.30%) has been found to be beneficial. Delay in sowing should be avoided to protect from different diseases.

Management of Insect-pests

Mustard aphid, mustard sawfly, painted bug, Bihar hairy caterpillar and leaf miner regularly appear and are of high economic value. Data generated on mode of damage, economic threshold and management of these major pests are discussed below:

(a) Mustard aphid (*Lipaphis erysimi* Kalt.)

The mustard aphid is pale-green soft bodied and about 1-2 mm long. The nymphs and adults suck the cell sap from various parts of the plant and live in colonies. Due to the sucking of plant sap, plants remain stunted, leaves show curling and yellowing, pods shrivel up and seeds do not develop in the infested pods. The infestation due to mustard aphid is more serious during the end of December to the middle of March. Their number becomes innumerable, covering inflorescence and pods.

In order to control the pest, the following measures are found to be more effective.

i) Wherever the aphid problem is serious and acute, the mustard varieties may be sown instead of rapeseed varieties which are more susceptible to the pest.

ii) Early sowings, i.e., in the first fortnight of October, escape the mustard aphid infestation.

iii) The removal of early infested twigs bearing stem mothers by the end of December is very useful.

iv) Spraying the crop with 0.025% Methyl Oxydemeton (Metasystox 25 EC) or 0.03% Diamethoate (Rogor 30 EC) or 0.025 Qunalphos (Ekalux 25 EC) mixed in 625, 850 and 1000 litres of water per hectare, respectively, depending upon the crop growth stages. Spraying should be done thrice at 15 days intervals starting from the end of December to early January when 9-19 aphids per plant are observed. Number of sprays may be reduced depending upon the severity of the pest. The above mentioned quantity of water is for high volume sprayer such as foot sprayer.

i) If the crop is to be used for 'Sagg' (Leafy vegetable)/ fodder purpose, it may be sprayed with 0.05% Malathion 50 EC (500 ml Malathion 50 EC mixed in 500 litres of water/ha) five times at 10 days intervals. Do not pluck the leaves within seven days after spraying.

ii) Spraying of insecticides should be done in the afternoon to avoid any adverse effect on pollinators.

iii) The quantity of water will be approximately one tenth of the normal spray of liquid if the motorized sprayer is used. However, the quantity of insecticides will remain the same.

b) Mustard sawfly (*Athalia proxima* Klug)

The adult fly is orange yellow with smoky wings and black veins. The young larvae is green having black head and about 4 mm long. The full grown larva is greenish-grey having five strips of black dots on the lower side of the body and about 1 cm long. Larva attacks the young crop. All leaves are damaged in case of heavy incidence. The pest appears in the month of October and causes more damage during October/ November.

Application of 10% BHC dust @25 kg/ha or spraying the crop with 0.2% BHC 50 wp (2 kg of BHC WP mixed in 500 litres of water/ha) controls the pest.

c) Painted bug (*Bagrada cruciferarum* Kirk)

The nymphs have a number of pale, brown and red markings on their bodies. The adults are pretty looking with yellow and orange markings. The nymphs and adults suck the cell sap from the foliage and pods causing drying up. The sucking of the leaf sap causes white blotchy spots. Its high population becomes a nuisance at threshing floor also. This pest appears at seedling stage and again at pod formation stage.

Application of 10% BHC dust @25 kg/ha at seedling stage or spraying the crop with Malathion 50 EC (0.05%), i.e., 500 ml Malathion 50 EC mixed in 500 litres of water/ha at seedling stage controls the pest. Second round of spraying with Malathion 50 EC may be given in March (after pod formation), if necessary.

d) Bihar hairy caterpillar (*Spilosoma obliqua* Walker)

The abdomen of the moth is bright-red with black spots. The thorax, antennae and eyes are black. The fore-wings have reddish tinge and the hind wings have dark brown spots. The newly hatched larvae are brown and feed gregariously (in groups) on the leaves of few plants. The fully grown caterpillars are about 4-5 cm long and have numerous dark brown long hairs on the body. The mature caterpillars spread to the whole field and cause huge loss to the crop. The pest is more serious on toria during droughts.

In order to control the pest, the affected leaves should be destroyed in the initial stages of infestation. This would reduce the spread of the pest. Destruction of the larvae in gregarious phase is quite easy and effective. The young caterpillars can be killed easily by dusting the infested crop with BHC 10% (25 kg/ha). Spraying the crop with 0.07% Endosulfan (Thiodan 35 EC) 1200 ml or 0.05% Dichlorvos (Nuvan 70 EC) 300 ml mixed in 600 litres of water/ha controls the pest.

TRANSFER OF TECHNOLOGY AND ON-FARM TRIALS OF RAPESEED AND MUSTARD

Basudeo Singh

Oilseed crops in India in 1986-87 occupied 18.69 million hectares with a production of 11.65 million tons and productivity of 613 kg/ha. Of the seven oilseed crops (groundnut, rapeseed-mustard, sesame, niger, safflower, sunflower and soybean) producing edible oil, rapeseed (*Brassica campestris* var. toria, yellow sarson and brown sarson) and mustard (*B. juncea*) are most important sources of edible oil after groundnut. In 1986-87, rapeseed-mustard contributed 20.8% to the area and 22.8% to the production of total oilseeds. Sixteen percent of the world production of rapeseed-mustard comes from India but the productivity of these crops in India is among the lowest. Productivity of rapeseed-mustard in India in 1985-86 was 694 kg/ha as compared to the world average of 1262 kg/ha. This situation calls for the analysis of the various factors responsible for low productivity. Most of the oilseeds are grown under rainfed situation in marginal and submarginal lands of low fertility. Inadequate use of inputs like fertilizer, quality seeds and pesticides are other important factors limiting productivity. The production of oilseeds, therefore, in India did not show any significant increase. This is evident from the fact that total oilseeds production in India increased from 9.63 million tons in 1970-71 to 11.45 million tones in 1986-87, only a marginal increase of about 19% in 16 years, Table 1. This increase has been possible mostly due to the expansion of area under oilseeds. On account of increasing the gap between supply and demand of edible oils, India started importing oil since 1976 when 170,000 tons of oil was imported at the cost of Rupees 990 million which increased to an estimated two million tons at an estimated cost of Rupees 10,000 million in 1987-88 (provisional. Table 2).

Anticipating the problem of scarcity of vegetable oil in the country. All India Coordinated Research Project on Oilseeds was started in 1967. A number of new and better varieties of various oilseed crops were developed and the package of practices for realizing maximum yield were also developed. Mere development of high production technology does not solve the problem by itself unless it is transferred to the users and is adapted by them. Therefore, transfer of high production technology developed at the research stations was taken up by launching varietal demonstrations and maximum production demonstrations with the following objectives, as the field demonstrations were found to be most effective too is amongst several means of communication to the farmers:

1. To popularize widely adapted high yielding, disease resistant and superior quality varieties of oilseed among farmers through varietal demonstrations.

2. To educate the farmers about latest package of practices for realising maximum yields.

Since the present meeting is meant to focus attention exclusively on rapeseed and mustard, the work done in the recent past on the Toria and mustard demonstrations by the scientists of this university only shall be discussed here. The varietal demonstrations of toria and mustard (Tables 3 and 4) on the farmer's fields revealed that only improved varieties under full package yielded 10-15% over the old variety. The maximum production

Table 1. All India production of nine oilseeds (million tons)

Oilseeds	1970-71	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87
Groundnut	5.111	5.005	7.223	5.282	7.085	6.436	5.121	6.080
Castor	0.136	0.204	0.310	0.344	0.405	0.470	0.308	0.237
Sesame	0.562	0.446	0.590	0.552	0.559	0.520	0.501	0.443
Rapeseed-Mustard	1.976	2.304	2.381	2.207	2.608	3.073	2.681	2.635
Linseed	0.474	0.423	0.483	0.375	0.444	0.389	0.376	0.343
Niger	0.128	0.146	0.160	0.118	0.176	0.148	0.192	0.132
Safflower	0.154	0.335	0.422	0.396	0.501	0.515	0.348	0.332
Sunflower	0.076	0.067	0.159	0.230	0.300	0.440	0.281	0.436
Soybean	0.014	0.442	0.352	0.491	0.614	0.955	1.024	0.835
Total	9.630	9.370	12.080	10.000	12.690	12.950	10.833	11.453

Table 2. Production and Availability of edible oils in India (1975-76 to 1987-88)

Year	Indigenous Production		Population	Imports		Total availability	
	Million tons	Per capita kg/year		Million tons	Million Rs	Million tons	Per capita kg/year
1975-76	2.79	4.6	60.3	-	-	2.79	4.6
1976-77	2.27	3.7	61.7	0.17	999	2.44	4.0
1977-78	2.63	4.7	63.1	1.29	7,115	3.92	6.2
1978-79	2.80	4.3	64.6	0.82	4,798	3.81	5.6
1979-80	2.41	3.7	66.0	1.15	6,172	3.56	5.4
1990-81	2.50	3.8	67.5	1.07	5,160	3.63	5.4
1981-82	3.22	4.7	69.0	0.99	4,496	4.21	6.1
1982-83	2.73	3.9	70.6	1.15	5,070	3.88	5.9
1983-84	3.28	4.6	72.0	1.63	13,190	4.92	6.8
1984-85	3.45	4.7	73.5	1.37	11,221	4.81	6.5
1985-86	3.03	4.0	75.1	1.18	4,890	4.21	5.6
1986-87	3.10	4.1	76.6	1.48	6,677	4.59	6.0
1987-88 (Provisional)	-	-	-	2.00	10,000	-	-

Table 3. Results of Toria varietal demonstrations

Year	No. of demonstrations	Varieties/yield (q/ha)				
		Type-9	PT-30	PT-303	BHAWANI	PT-507B
1980-81	2	1140	1127	-	-	-
1981-82	6	1392	1392	1391	-	-
1982-83	4	1156	1390	1363	-	-
1983-84	4	1206	1331	1325	-	-
1984-85	3	1242	1366	1392	-	-
1986-87	6	-	1181	1382	981	1376
Overall mean		1191	1298	1371	981	1376

Table 4. Results of mustard varietal demonstrations

Year	No. of demonstrations	Varieties/yield (Q/ha)			
		VARUNA	PR-15	PR-18	PR-35
1982-83	3	1350	1542	1543	-
1983-84	3	1475	1583	1650	-
1984-85	7	-	1603	1603	1563
1986-87	6	-	1790	1768	-
Overall mean		1413	1630	1641	1563

demonstration of toria and mustard, (Tables 5 and 6) indicated that per hectare productivity of over 13 quintals in case of toria and over 17 quintals in case of mustard against the existing productivity of 6 to 7 quintals can be easily obtained under optimum management of the crop which comes to 2-3 times of existing productivity, (Tables 7 and 8). Transfer of improved technology of rapeseed mustard production is being done through various extension projects like Lab to Land Project, National Oilseeds Development Project, National Demonstration Schemes, Operational Research Project, Oilseeds Production Thrust Project and Land to Lab Project.

During the course of conduct of the demonstrations on the farmer's fields, it was found that even in the best managed fields the yields realized at the research stations were often not repeatable. These were just 50 to 70% only. This was true to even those farmers' fields which were located near the research stations. However, in some cases, the crop and yields were as good as at the experiment station. These could be attributed to the variations in soil texture, structure, effects of previous cropping history upon fertility, nutrient and micro-nutrient status of the soil, etc. The failure of the technology generated at the research station to provide repeatable performance at the farmers' fields revealed the weakness of the technology as it

Table 5. Results of Toria maximum production demonstrations

Year	No. of demonstrations	Average yield kg/ha	Cost of production (RS/HA)	Net profit (RS/HA)	Selling rate (RS./Qt)
1980-81	10	1261	1472	3573	400
1981-82	5	1389	1049	2837	358
1982-83	11	1182	1799	2932	400
1983-84	7	1374	1895	3600	400
1984-85	5	1370	1929	4236	450
1986-87	3	1192	2317	3641	450
1987-88	5	1829	2317	5914	450
Overall mean		1364	1940	3819	414

Table 6. Results of mustard maximum production demonstrations

Year	No. of demonstrations	Average yield kg/ha	Cost of production (RS/HA)	Net profit (RS/HA)	Selling rate (RS./Qt)
1980-81	3	1331	1509	3815	400
1982-83	2	1788	2467	4668	400
1983-84	4	1896	2487	4097	400
1984-85	6	1788	2650	5396	450
1985-86	8	1872	2858	4630	400
1986-87	6	1479	3104	4381	450
Overall mean		1715	2628	4582	420

Table 7. Production of mustard under maximum production demonstrations and productivity in different districts in 1987-88

District	Area (ha)	Experimental Yield (kg/ha)	Rapeseed-mustard productivity of the district (kg/ha)
Saharanpur	0.4	1500	661
Moradabad	0.4	2263	592
Baduan	0.4	1550	696
Bulandshahr	0.4	1531	661
Meerut	0.4	2300	661
Mean		1829	654

Table 8. Yield obtained at farmers' field under block demonstration and productivity of mustard under different districts

District	Area (ha)	Experimental Yield (kg/ha)	Rapeseed mustard productivity of the district (kg/ha
Bareilly	4	851	696
Rampur	22	2000	592
Moradabad	4	1850	592
Shahjahanpur	128	1600	602
Haldwani (Nainital)	4	1500	529
Rudrapur (Nainital)	8	1844	529
Mean		1608	590

did not take into account all possible factors which are likely to be encountered at the farmers' level at the adoption stage. Besides, research trials at experiment stations are so well managed that all the inputs are provided upto the maximum economic level at most appropriate time. Thus the basic assumption in technology generation is that there is no dearth of resources at the farmers level for crop production. Whereas the fact is that the majority of the farmers do not have enough resources to provide all the recommended inputs for maximum production eventhough they are aware of their importance. This results in a poor adoption of technology.

From the conduct of the varietal and maximum production demonstrations, visit of the farmers' fields and frequent interaction with the farmers, it was found that applications of full packages were beyond the capacity of the marginal and sub-marginal farmers who constitute the majority of the farming community. Therefore, research work was undertaken to determine the effect of individual components of the package of practices on yield so that individual components may be listed in descending order for being applied by the farmers according to their capacity. This was determined separately for Toria and mustard, (Tables 9 and 10).

The study on the effect of important components of package of practices in case of Toria, (Table 9) revealed that replacement of local variety by standard and improved ones resulted in an increase of 42.6% in seed yield.

Table 9. Effect of important component of package of practices at Pantnagar

Treatments	Seed Yield	Increase in Yield	
	q/ha	q/ha	%
Local Variety (Farmers' Practice)	10.06	-	-
Standard Variety (S.V.)	14.35	4.29	42.6
S.V. + Fertilizer	15.74	5.68	56.46
S.V. + Irrigation	13.52	3.46	34.39
S.V. + Fertilizer + Irrigation	17.17	7.11	70.06
Full package of practices	17.03	7.77	77.22

Table 10. Contribution of each package of production in mustard based on five years average

Treatments	Yield q/ha	Increase in Yield		Cost benefit ratio
		q/ha	%	
Local Variety	5.89	-	-	-
Standard Variety (S.V.)	7.09	1.20	20.3	1:19
S.V. + Fertilizer	11.33	5.24	88.9	1:3.4
S.V. + Irrigation	8.86	2.17	36.8	1:5.4
S.V. + Plant protection	10.53	4.64	78.8	1:8.3
S.V. + Fertilizer + Irrigation	14.43	8.54	145.0	1:4.5
S.V. + Irrigation + Plant Protection	10.19	4.30	73.0	1:4.1
S.V. + Fertilizer Plant Protection	13.64	7.75	131.6	1:3.6
Full package of practices	17.78	11.89	201.8	1:4.7

The seed rate of Toria being low (5 kg/ha), the improved seed was found to be the cheapest input with highest benefit-cost ratio which was followed by improved seed and fertilizer increasing together the yield by 56.45%. Adoption of full package increased the yield by 77.23%. We discussed our findings with farmers and recommended that simple with improved variety would bring maximum economic return and beneifit-cost ratio. Some of the farmers agreed to try our recommendation to the extent that they would only replace the traditional variety. Varietal trials were thus laid out at three farmers' fields and an average increase of 23% in yield of Toria was recorded by simple replacement of the old variety (T9) by the new variety (PT 303) developed at this university. Thus, this variety became very popular, (Table 11).

Table 11. Mean yield (kg/ha) of improved and local varieties under on-farm trials Toria (1987-88, late sown) at farmer's practices

Varieties	Locations 1	2	3	Overall mean	Superiority over local(%)
PT-303	750	750	1267	922.3	23
PT-855	562	375	1050	662.3	-12
T-9 (Local)	450	750	1050	750.0	-

In another experiment, it was found that sowing of Toria in rows, 30 cm apart enhanced the yield by 15 to 25%. On-farm trials were laid out at five farmers' fields to test the validity of the treatment at the farmers' fields and it was found that line sowing was superior to broadcasting by 22%, Table 12.

Table 12. Effect of method of sowing on seed yield (kg/ha) of Toria under on-farm trials (1987-88)

Method of sowing	Locations 1	2	3	4	5	Overall mean	Superiority (%)
Line sowing	900	725	700	770	800	779	22
Broadcasting	740	575	550	630	700	639	-

Elaborate experiments conducted over five years with mustard to find out the effect of individual components of the package of practices revealed that replacement of local variety by the improved one increased the yield by 20.3% and provided maximum benefit-cost ratio (1:19). This observation was similar to the one recorded in case of Toria. This was followed by the use of standard variety and plant protection which provided cost-benefit ratio of 1:8.3. Adoption of full package enhanced the yield to 17.78 q/ha as compared to 5.89 q/ha in case of local variety and farmers' practices, Table 10.

Our work on on-farm trials was limited and very simple to demonstrate, to the farmers, the effect of individual components which are cheaper and more easily adoptable by the farmers and give maximum benefit-cost ratio only in a specific cropping system. In fact, on-farm trials should take into account the various cropping systems, production practices, pest infestation, economic and social conditions of the farmers and ultimately the whole farming system. These are to be based on the survey and identification of the target group of farmers which represents the majority of the farmers on the basis of holding size. Thereafter, the on-farm trials should be designed:

i) to understand the farming conditions and farmers constraints,

ii) to know the precise objectives of the farmer in a farming system in order to provide proper weightage to different treatments,

iii) to accomplish the testing of technology at the farmers' field while it is still under development so that it has greater likelihood of acceptance, and,

iv) to start involving extension with research from the early stage. This would improve the level of adoption of the new technology generated at the experiment station and the results and conclusions of the on-farm trials should be considered complementary to the outcome of on-station trials.

STATUS OF BREEDING RESEARCH ON BRASSICA OIL CROPS AT PANTNAGAR, INDIA

G.N. Sachan

Abstract

Research on rapeseed-mustard breeding at Pantnagar was started in the year 1967. Two varieties of Indian mustard (*Brassica juncea*), Kranti and Krishna, and two varieties of toria, PT 303 and PT 30, have been released for commercial cultivation. PYS-6 and PYS 841, varieties of yellow sarson, and PT 507B, a variety of toria have been identified for release. Besides, a number of promising strains of toria, yellow sarson and Indian mustard are in advanced stages of testing.

Male sterility sources in toria and yellow sarson have been discovered and efforts are underway to isolate maintainer/ genetic marker. A source of dwarfing gene(s), named bunchy dwarf discovered in toria at Pantnagar, is being used to develop dwarf varieties with early maturity, lodging resistance and better response to better management. Interspecific hybridization to evolve disease and insect resistant varieties of mustard with good quality of oil is in progress.

Brassica oil crops (rapeseed-mustard) grown in India include toria, yellow sarson and brown sarson (*B. campestris* L.) and Indian mustard (*B. juncea* (L.) Czern and Coss). These crops are grown during rabi season (September-March) and are highly variable in mating systems (Self-compatible to self-incompatible), maturity duration (early to late), seed color (yellow to black), seed size (small to bold) and oil content (35-45%), Table 1. Recently gobhi sarson (*B. napus* L.) has been added to the existing list of Brassica oil crops.

Rapeseed-mustard, which are at second place in area and production after groundnut in India, occupy about 2.88 million hectares area with an annual production of about 2.64 million tones at a productivity level of 694 kg/ha, which is much lower than world's average (1262 kg/ha). The cultivation of rapeseed and mustard is mostly confined to the northern states of the country, though some area can be found in other states. The state of Uttar Pradesh in which G.B. Pant University of Agriculture and Technology is located contributes upto 35% to the national acreage and about 27% of the production of rapeseed-mustard.

Research Achievements

Research on rapeseed-mustard breeding at Pantnagar was started in 1967. Two varieties of Indian mustard, Kranti and Krishna, and 2 varieties of toria, PT 303 and PT 30, have been released for commercial cultivation, Table 2. PT 507B, a variety of toria and PYS-6 and PYS 841, varieties of yellow sarson, have been identified for release, Table 3. Besides, 109 promising strains of toria, 37 of yellow sarson and 86 of Indian mustard are being evaluated for their yield performance in multilocation trials of All India Coordinated Project on Oilseeds (AICORPO), Uttar Pradesh State Varietal Trial and Station trials at Pantnagar.

A source of dwarfing gene(s) viz; bunchy dwarf mutant in toria and male sterility sources in toria and yellow sarson have been discovered and are being used in the varietal improvement program.

Table 1. Important characteristics of Brassica oil crops grown in India

Botanical name	English name	Common name	Mating system*	Maturity duration (days)	Seed color	Seed size	Average Oil content (%)
B. campestris var.Toria	Indian rape	Toria	SI	Early (80-100)	Brown	Small	40
B. campestris var. Yellow sarson	Yellow sarson	Yellow sarson	SC	Medium (110-120)	Yellow	Bold	45
B.campestris Var. Dichotoma	Brown sarson	Kali sarson	SC (Toria) SI Lotania)	Medium (110-120)	Reddish brown	Medium	42
B. juncea	Indian mustard	Rai	SC	Medium to late (120-140)	Brown	Medium to bold	42

*SI = Self-incompatible, SC = Self compatible.

Table 2. Varieties of rapeseed and mustard developed at pantnagar

Variety	Breeding method and pedigree	Maturity duration (days)	Yield (q/ha) Maximum at research plot	Averages at farmers' fields	Oil content (%)	Tolerance to diseases and insects
Kranti	Pure line selection from Varuna	125-130	30	18-20	40.0	Alternaria blight, White rust, Downy mildew
Krishna	Pure line selection from Varuna	132	30	19-21	40.4	Mustard sawfly, Mustard aphid
PT 303	Hybridization (DSH17 MD x B-54)	90-95	25	15-18	42.8	Alternaria blight, White rust Downy mildew
PT 30	Composite breeding (Polycross)	93	25	14-16	41.9	Alternaria blight, white rust, Downy mildew

Table 3. Pantnagar varieties identified for release

Variety	Breeding Method and Pedigree	Superiority over standard (%)	Recommended areas
PYS 6	Pure line selection from Local	35.12	Rainfed areas of Bihar, Orissa and West Bengal
PT 507B	Composite breeding (6 components)	17.20	Rainfed areas of Bihar, Orissa and West Bengal
PYS 841	Pure line selection from Local	10.0	Rainfed areas of Uttar Pradesh and Madhya Pradesh

Research Objectives And Work In Progress

1. Collection, Evaluation and maintenance of germplasm

Genetic stocks of oleiferous Brassica including land races are collected every year from other countries through National Bureau of Plant Genetic Resources (NBPGR), New Delhi, and farmers' fields through visits.

All the available germplasm lines of toria, yellow sarson and mustard have been evaluated over the years. The lines found better in seed yield are included in station trial (direct use) and the lines desirable for specific character(s) are included in hybridization programs as donor parents.

In order to conserve the variability, self-compatible types are maintained by natural selfing and self-incompatible types by forming gene pools.

2. Varietal Improvement

i. Development of high yielding and widely adapted varieties of rapeseed and mustard: To develop high yielding, and widely adapted varieties of rapeseed-mustard, different breeding procedures, such as, Pure line selection, mass selection, progeny selection, development of composites and hybridization (single cross, double crosses), etc., depending upon the mode of reproduction of crop, are being used. The following sources are being used as donor parents for different characters:

Character	Toria	Yellow Sarson	Mustard
High yield	PT 303, PT30	PYS 6,PYS 841	Kranti
	PT 507B		Krishna
Bold	DSH 17 MD	YST 151	Pusa Bold
	(Var. of		RJ 5
	Brown Sarson)		RH 8313
Yellow seed	PYS 6, PYS 408	-	TM 12

ii. Development of early varieties of toria and mustard: With a view to evolve early varieties of toria (less than 85 days) and Indian mustard (less than 130 days) to fit in multiple cropping system using D-1, D-2, D-3, D-6, Bhawani, TS-29, M 27 and NDT 8501 varieties of toria, and PR 1108, Poorbiraya, Seeta and RW 4-6 (3/11) varieties of Indian mustard, as donor parents is in progress. Twenty seven F_1s and 5F_2s of toria, and 10F_1s and 6F_2s of Indian mustard have been grown for advancing the generation and selection of desirable plants.

Five populations and five experimental composites of toria, synthesized by mixing equal quantity of seeds of selected varieties and single crosses, respectively, have been grown in isolation for random mating. Besides, 13 improved strains of toria developed through mass selection are being evaluated for their yield performance.

iii. Development of dwarf varieties of toria: A source of dwarfing gene(s) having compact arrangement of branches and siliquae and dwarf plant type (30-80 cm height) is being used to evolve dwaf varieties with early maturity, lodging resistance and better response to better management practices.

To fix the dwarfing gene(s), selfing and sibbing in bunchy dwarf plants is being followed. In the previous crop season, 53 plants were selfed, 26 lines were sibbed and 173 individual plants were selected. Besides, four populations derived from bunchy dwarf progenies were grown in isolation with rigorous rouging. Progenies of all these have been grown for further evaluation and selection.

iv. Development of hybrid varieties of toria and yellow sarson: Male sterility sources in toria and yellow sarson have been discovered at Pantnagar. Efforts are being made to identify genetic marker/ maintainer lines. Male sterile x male fertile crosses of toria and yellow sarson along with the parents have been grown for further evaluation and crossing.

v. Development of mustard varieties suitable for mixed cropping and late sowing: Despite the fact that pure crop of mustard gives better return, in many areas farmers still continue with the mixed cropping of mustard with wheat and some of the rabi pulses. Sowing time of latter crops is usually November, whereas the normal sowing time of mustard is the first fortnight of October. Therefore, the work on the development of varieties having top branching, deep root system, less foliage and giving higher yield in late sowing is in progress.

PR 43 and PR 35 which are suitable for mixed cropping have already been recommended for inter-cropping with wheat in West Bengal, Uttar Pradesh and Haryana. Some newly developed promising strains are being evaluated under late sown conditions in station trials. Besides, $2F_1$s, $8F_2$s and $6F_3$s involving PR 43, PR 35, Vardan and Laha 101 as donor parents have been grown for advancing the generations and selection.

3. Resistance Breeding

i. Development of diseases and insect resistant/ tolerant varieties of mustard through intervarietal hybridization: RC 781 and PHR 1, strains of Indian mustard, have been found resistant/tolerant to Alternaria blight. These lines are being used as donor parents for developing Alternaria resistant/tolerant varieties of mustard. During the previous crop season, $9F_1$s, $9F_2$s and $7F_3$s were grown and disease inoculum was sprayed twice after flowering to make the selection effective. Desirable plants from different crosses were selected and have been grown for further screening. Besides, seven promising lines are being evaluated for their yield performance.

A mustard strain, YRT 3, reported as resistant to downy mildew and white rust is being used as a donor parent. Twenty two F_3s involving YRT 3 as donor have been grown for further evaluation and selection of desirable plants.

T-6342, RW 4/86, RW 3-85 (glossy white flower), RW 15-6 and RW 2-2, strains of Indian mustard, are being used as donor parents for developing aphid resistant/tolerant varieties. Thirteen F_2s and $6F_3$s have been grown under natural conditions (without spray of insecticide) and desirable plants will be selected. Besides, 2 promising lines are being evaluated for their yield performance.

ii. Development of disease and insect resistant / tolerant varieties of mustard through interspecific hybridization: Screening experiments have revealed that a certain level of resistance to Alternaria blight is present in *B. napus*, *B. carinata* and *Sinapis alba*. Similarly, *B. carinata*, *S. alba* and *B. tournifortii* were found to have a certain degree of resistance to mustard aphid. Therefore,interspecific hybridization of cultivated varieties of Indian mustard (as female parent) with the above mentioned species is in progress.

Fifty eight F_1s, 40F_2s, 30F_3s and 25F_4s were grown and screened for Alternaria blight and aphid resistance during the previous crop season. At maturity, desirable plants showing resistance were selected from different crosses. These selections have been grown for further evaluation. Besides, 87 fresh crosses (single and multiple crosses) made during the previous crop season have been grown for further screening. In addition to these, 41 promising lines derived through interspecific hybridization are being evaluated for yield performance.

4. Quality Breeding, Development of rapeseed and mustard varieties with low erucic acid in oil

In order to develop rapeseed and mustard varieties with low erucic acid in oil, intervarietal and interspecific hybridization using the following sources is in progress:

B. campestris : Candle, Tobin, Torch
B. juncea : ZEM-1, ZEM-2
B. napus : Altex, Tower, Regent, Wester

Five F_1s and 6F_2s derived from inter-varietal hybridization and 10F_1s, 10F_2s and 7F3s derived from inter-specific hybridization have been grown, from which desirable plants will be selected. Besides, 18 improved lines derived through intervarietal hybridization and one through interspecific hybridization are being evaluated for their yield performance.

Future Strategies

A break through in oilseed production could be possible with technological break through. Possibilities for exploiting hybrid vigour in toria by developing hybrid varieties through the use of available male sterility has a promise. Lodging resistant dwarf varieties, responsive to better management practices, may be helpful in quantum jump of yield of toria. Multiple resistance to diseases and insects in agronomically superior genotypes could be possible in the future with the genetic material in hand from intra and interspecific hybridizations. Tissue culture techniques, anther and microspore culture, may be used for developing homozygous lines in a shorter period of time. Ovule culture and protoplast fusion may be used as a tool in making successful wide crosses to develop disease and insect resistant varieties of rapeseed and mustard.

AGRONOMIC INVESTIGATIONS ON RAPESEED AND MUSTARD AT PANTNAGAR

Arvind Kumar and R.P. Singh

Oilseed crops which are next to cereals in production of agricultural commodities in India, occupy a premier position in the national economy because vegetable oils are essential raw materials for various industrial products apart from being an essential part of the human diet. Presently, being cultivated on 18.69m ha oilseed crops constitute about 11.5% of the total cultivable land which is 163 m ha. Inspite of this substantial acreage, the present level of production, only 11.45 m tones in 1986-87, has failed to set right the situation created by conspicuous growth in consumption demand. During the 1987-88 alone, the Government of India has to import 1.8 m tones of edible oils costing nearly 10,000 m Rs. to meet the domestic requirements of fats and oils.

Rapeseed and mustard occupy a prominent position next to groundnut in India. It is the major rabi oilseed crop of India and the major oilseed crop of U.P. State. Rapeseed-mustard occupied 3.73 m ha, (20% of the total area under oilseeds during 1986-87). In terms of production, 2.63 m tones of rapeseed-mustard was produced which constituted 23% of the total oilseed production in the country.

Uttar-Pradesh is the main rapeseed and mustard growing state and accounts for about 26% of the total area and 25% of the total production of these crops in the country. The U.P. state has, however, about 54.24% area and 67.22% production of rapeseed-mustard, out of the total oilseeds grown in the state. The productivity of the crop in U.P. is 6.12 q/ha which could be increased to a greater extent, as the recently released varieties are capable of yielding upto 30 q/ha.

The researches done have indicated that it is possible to considerably step up rapeseed-mustard production by utilizing the new varieties and production technology. The causes of poor production are many and often complex ones. However, the major ones could be: small acreage under improved varieties, non-adoption of improved package of practices and the cultivation of these crops on marginal and sub-marginal lands under poor package of plant protection practices. Agronomically, delayed sowing, poor plant stand, lack of optimum fertilization schedule, poor irrigation facilities, inadequate weed control and vagaries of nature often accentuate the difficulties in the production of these crops and, at times, severely affect the realization of even their existing yield potential. The agronomic requirements of rapeseed and mustard for obtaining higher yields based on the research work done at Pantnagar during the tenure of IDRC/ICAR-assisted project are listed below:

1. Varietal performance

With the adoption of improved varieties, an increase in yield ranging between 2.8 to 27.7% in Toria, Table 1, and 7.5 to 12.0% in mustard, Table 2, has been recorded. PT 507 B in Toria and Krishna in mustard gave highest yields.

Table 1. Performance of Toria varieties.

Varieties	Seed yield (q/ha)	Increase over T-9 (%)
PT-30	13.58	2.8
PT-303	15.94	20.6
PT-507 B	16.87	27.7
T-9	13.21	-

Table 2. Performance of mustard varieties.

Varieties	Seed yield (q/ha)	Increase over T-9 (%)
Varuna	15.59	-
Krishna	17.46	12.00
Vardan	16.89	8.33
Kranti	16.77	7.56
Pusa bold	17.16	10.00

2. Sowing time

Sowing time is the single most non-monetary input affecting the yield of rapeseed and mustard to a greater extent. Since these crops are thermo-sensitive in nature, Sowing at the right time is necessary to provide an optimum temperature during a particular growth phase. The loss in yield due to delayed sowing cannot be compensated by higher doses of nitrogen or a high population. The optimum sowing time is also determined, keeping in view the vagaries of low temperature or frost and the occurrence of pests and diseases in a locality. Late sowing generally tends to give lower yield of seed as well as oil which may primarily be due to shorter duration of reproductive phase and thus allowing less time for the formation of siliquae and the development of seeds. It also causes higher incidence of diseases and pests.

The sowing time of Toria may vary with the pattern of withdrawal of monsoon and the crop sequence which may vary from early September to early October. At Pantnagar, the reduction in seed yield in 11 October sowing over 27 September sowing was noted to the extent of 28% in Toria, Table 3. For mustard, the optimum sowing time is the first week of October. In delayed sowing, the incidence of aphids and *Alternaria* blight is comparatively more. The yield reduction in one month delayed sowing has been noted to the extent of 45% in comparison with that of 1 October sowing, Table 4.

Table 3. Effect of sowing time on mustard, pooled over two years.

Sowing date	Seed yield (q/ha)	Reduction below 1.10	Oil content %	Oil yield (q/ha)
1/10	17.4	-	41.4	7.2
11/10	14.0	-19.5	40.2	5.6
21/10	11.7	-32.7	39.1	4.6
31/10	9.5	-45.4	38.5	3.7

Table 4. Effect of sowing time on toria, pooled over two years.

Sowing date	Seed yield (q/ha)	Reduction below 27.09	Oil content %	Oil yield (q/ha)
20/09	13.4	37.8	5.0	-3
27/09	13.8	38.6	5.3	-
4/10	12.8	37.0	4.7	-7
11/10	9.9	34.0	3.4	-28
18/10	8.3	31.0	2.6	-48

3. Establishment of plant stand

Establishment of optimum plant stand is a real bottle neck in the realization of good harvest of rapeseed and mustard, particularly under dry land situations. To overcome this problem, sowing should be done in furrows. The use of this technique, not only helps in maintaining perfect stand but also better conservation of moisture. While sowing, care should be taken to sow the seeds in lines not deeper than 4 cm and should not be mixed with drilled fertilizer. The optimum row-to-row distance for Toria has been found to be 30 cm, Table 5, and for mustard 45 cm, Table 6. The oil yield was also maximum at this row spacing. Thinning of plants at about 15 days after sowing is also necessary in order to maintain plant spacing of 15 cm.

Table 5. Effect of row spacing on Toria, pooled over two years.

Row spacings*	Seed yield (q/ha)	Oil content (%)	Oil yield (q/ha)
20 cm	10.8	36.6	3.9
30 cm	13.1	36.5	4.8
40 cm	14.7	36.4	5.3

* Plant-to-plant spacing 15 cm (by thinning).

Table 6. Effect of row spacing on mustard, pooled over two years.

Row spacings*	Seed yield (q/ha)	Reduction below 45 cm (%)	Oil content (%)	Oil yield (%)
30 cm	13.4	-3.6	41.8	5.6
45 cm	13.9	-	40.5	5.6
60 cm	12.2	-12.2	40.2	4.9

* Plant-to-plant spacing, 15 cm (by thinning).

The recommendations of seed rates are 4 and 5 kg/ha for Toria and mustard, respectively. The use of high seed rate is disadvantageous and results in a competition for nutrients and space which in turn causes poor branches. Plant population level of 0.22 million per hectare in Toria and 0.15 million per hectare in mustard is desirable and should be maintained by thinning. Line sowing and thinning gave 28.7% yield increase in Toria, Table 7, and 10.9% in mustard, Table 8, over broadcasting. In late sown mustard, the planting geometry level of 30 cm x 15 cm recorded highest seed and oil yields, Table 9. Higher plant population level had adverse effect on seed yield.

Table 7. Effect of planting technique on Toria, pooled over two years.

Treatment*	Seed yield (q/ha)	Increase over broadcast (%)
Broadcasting (4 kg/ha)	12.5	-
Broadcasting (6 kg/ha)	13.4	7.5
Line sowing (30cm without thinning)	14.9	19.48
Line sowing (30 cm with thinning	16.0	28.78

*Plant-to-plant spacing 15 cm (by thinning)

Table 8. Planting technique on mustard, pooled over two years.

Treatment*	Seed yield (q/ha)	Increase over broadcast (%)
Broadcasting (45 kg/ha & 120 kg N/ha)	12.8	-
Line sowing (45 cm-no thinning and 120 kg N/ha)	13.4	4.7
Line sowing (45 cm-thinning & 120 kg N/ha	14.2	10.9

*Plant-to-plant spacing 15 cm (by thinning).

Table 9. Plant geometry in mustard under late sowing Seed conditions, pooled over two years.

Planting geometry levels (cm)	Seed yield (q/ha)	Reduction below 30x15 (%)	Oil content (%)	Oil yield (q/ha)
20 x 15	12.1	-40.0	39.7	4.8
20 x 20	13.4	-33.6	39.5	5.3
30 x 15	20.2	-	41.7	8.4
30 x 20	18.3	-9.4	41.4	7.6
45 x 15	16.7	-17.3	39.8	6.6

4. Optimum fertilizer use

Rapeseed and mustard respond to nitrogen application almost invariably and to phosphorus, sulphur and some micro-nutrients under certain conditions. The effect of nitrogen fertilizer can be optimized by its split application. The application of half of the recommended dose in furrows, as basal (4 cm below the seed) and half as top dressing after first irrigation gives better utilization of nitrogen and higher seed yields, Table 10. Farmers usually do not adopt the recommended nitrogen which also causes reduction in seed yield.

For irrigated situation, the response up to 90 kg N/ha in Toria and 120 kg N/ha in mustard, have been obtained. In Toria, with the application of 60 and 30 kg N/ha, the yield reduced to the extent of 14 and 19% below 90 kg N/ha at Pantnagar, Table 11. The net returns were also maximum at this level. In mustard, the application of 120 kg N/ha has higher yield and net returns. The reductions in seed yield at 75% and 50% of the recommended dose were 11.3 and 28.5% respectively, Table 12.

Table 10. Effect of method of nitrogen application on mustard, pooled over two years.

Treatments	Seed yield (q/ha)	Increase over basal (%)
Whole as basal	13.7	-
2/3 basal + 1/3 at 25 DAS*	15.3	11.6
1/3 basal + 2/3 at 25 DAS	15.1	10.2
1/2 basal + 1/2 at 25 DAS	17.0	24.0

* DAS - Days after sowing.

Table 11. Effect of nitrogen fertilization on Toria, pooled over two years.

N-rate (kg/ha)	Seed yield (q/ha)	Reduction below 90 (%)	Oil content (%)	Oil yield (q/ha)	Net returns (Rs/ha)
30	16.2	-19.1	41.9	6.8	4526
60	17.2	-13.9	40.2	6.9	4760
90	20.0	-	39.9	8.0	5615
120	19.0	-5.0	36.7	7.3	5452

Table 12. Effect of nitrogen fertilization on mustard, pooled over two years.

N - rate (kg/ha)	Seed yield (q/ha)	Reduction below 120 (%)	Net returns (Rs/ha)
120 Recommended	18.6	-	4955
90	16.5	-11.3	4359
60	13.3	-28.5	3354

5. Micronutrient fertilization

Crop yields are poor in sulphur deficient soils. Response to upto 30 kg/ha sulphur application has been obtained, Table 13. The application of Pyrite of $CaSo_4$ could be made for adding sulphur, Table 14. Sulphur @ 20 kg + Zinc @ 10 kg/ha and sulphur @ 20 kg + Boron @ 1 kg/ha gave the highest increase in yield over the control.

Table 13. Effect of micro-nutrient fertilization on mustard, pooled over two years.

Treatments	Seed yield (q/ha)	Increase over control (%)
Sulphur @ 20 kg/ha	13.8	16.9
Sulphur @ 30 kg/ha	15.5	31.3
Zink @ 10 kg/ha	12.6	6.7
Boron @ 1 kg/ha	13.0	10.1
Sulphur @ 20 kg + Zinc @ 10 kg/ha	16.2	37.2
Sulphur @ 20 kg + Boron @ 1 kg/ha	15.0	27.1
Control	11.8	-

Table 14. Seed yield (q/ha) as influenced by different levels and sources of sulphur (1987-88)

Rate (kg/ha)	Source	Seed yield (q/ha)	Increase over control (%)
Control		9.80	6.4
20	Pyrite	10.43	6.4
20	$CaSo_4$	10.10	3.0
40	Pyrite	11.33	15.6
40	$CaSo_4$	11.89	21.3
60	Pyrite	11.45	16.8
60	$CaSo_4$	11.01	12.3
CD at 5%			NS

6. Water management

Rapeseed and mustard are usually raised under rainfed conditions or conserved moisture received from the monsoon rains. About 47.5% of the total area under these crops is irrigated in U.P. Under rainfed conditions, the yield level of such crops is governed mainly by the extent of moisture stored in the soil profile. Good yield from such areas can be obtained if the fields are levelled and bunded before the monsoon. In Toria, one irrigation applied at 25 days after sowing proved to be beneficial and gave 9.6% increase over the control, Table 15. In mustard, in addition to one irrigation at 25 days after sowing, a second irrigation was applied at pod formation stage. The increase in seed yield with two irrigations was 73.4% over no irrigation. In case of limited water supply, only one irrigation at flowering increases the yield. The response to nitrogen fertilization is very conspicuous under irrigated conditions. Pre-sowing irrigation is also necessary for having optimum plant stand in mustard. Irrigation at 0.6 IW/CPE ratio gave highest yield in mustard.

Table 15. Effect of irrigation on Toria and mustard, pooled over two years.

Irrigation levels	Seed yield (q/ha)		Increase over control (%)	
	Toria	Mustard	Toria	Mustard
No irrigation (control)	12.5	7.9	-	-
One irrigation	13.7	11.9	9.6	50.6
Two irrigations	14.1	13.7	12.8	73.4

7. Weed control

Yield reduction, in mustard, due to the presence of weeds has been reported to be 24-70% depending upon the weed species, their intensity and time of occurrence. The conventional method of hand weeding is not only labour-consuming but also costly. The three herbicides, viz., Fluchloralin, Isoproturon and Pendimethalin have been found to be effective in mustard. Pre-plant incorporation of Fluchloralin @ 1.25 kg/ha and pre-emergence application of Pendimethalin @ 1.25 kg/ha can be made. However, in light-textured soils, the dose may be reduced. If the weeds emerge late after sowing, the use of Isoproturon @ 0.75 kg/ha at 30 days after sowing can be made. This may also suit the farmers who grow wheat in association with mustard.

In case of gram + mustard, pre-plant incorporation of Fluchloralin @ 0.75 kg/ha is done for controlling weeds. Among grassy weeds. *Avena fatua* and *Cynodon dactylon* were pre-dominant, amounting to 15.3 and 33.3%, respectively, of the total weed population at maturity. Among broad-leafed weeds, *Melilotus alba* followed by *Vicia sativa* had the maximum percentage compared to the unweeded control. Higher weed control efficiency was recorded with the application of Fluchloralin.

8. Effect of Phyto-hormones

Application of Ethrel @ 500 ppm and NAA @ 100 ppm at bud emergence stage increased the seed yield of mustard under late sowing conditions, Tables 16 and 17.

Table 16. Effect of Phyto-hormones on mustard, pooled over two years.

Hormone levels	Seed yield (q/ha)	Increase over water (%)	Oil content (%)	Oil yield (q/ha)
NAA-100 ppm	16.2	16.5	37.8	6.1
GA_3-10 ppm	13.7	-	35.4	4.8
Ethrel-500 ppm	16.8	20.8	39.7	6.7
Water spray	13.9	-	37.4	5.2

Table 17. Effect of spray stage of Phyto-hormones on mustard, pooled over 2 yrs

Stage of spray	Seed yield (q/ha)	Oil content (%)	Oil yield (q/ha)
Rosette	14.7	39.2	5.8
Bud emergence	15.2	39.2	5.9
Flowering	14.8	38.2	5.6

9. Intercropping practices

(i) Intercropping with sugarcane: This give better monetary returns in comparison with sole crop of sugarcane. Therefore, autumn-planted sugarcane may be intercropped with these crops. The production practices are the same as those recommended for the cultivation of pure crop of sugarcane, except that, one row of these crops is sown between tow rows of sugarcane. If the growth conditions are poor and the growth of sugarcane is inadequate, two rows can be grown.

(ii) Intercropping with lentil: This had higher monetary returns over pure cropping. Toria and lentil grown in 1:1 ratio gave maximum net returns, Table 18.

Table 18. Intercropping of Toria and lentil, pooled over two years.

Treatments	Seed yield (q/ha)		Seed yield equivalents of toria		Net* returns (Rs/ha)
	Toria	Lentil	1986-87	1987-88	
1. Pure toria (30 cm row)	12.75	-	8.51	16.09	7474
2. Pure lentil (30 cm row)	-	20.35	15.81	8.43	6236
3. Toria + lentil (1:1 row distance 20 cm)	8.18	14.68	18.15	17.20	10735
4. Toria + lentil (1:1) row distance 30 cm	7.38	13.90	15.61	18.62	10960
5. Toria + lentil (broadcasting)	9.24	10.50	14.23	16.85	9770

* Based on the prevailing market time at harvest.

(iii) Intercropping with gobi sarson: This gave higher returns over pure cropping. Sowing of Toria (30 cm apart) followed by toria + G.sarson (1:1 ratio - 22.5 cm) gave better results, Table 19.

Table 19. Seed yield and gross returns in Toria + Gobhi sarson intercropping system (1987-88)

Treatments	Seed yield (q/ha)		Total yield (q/ha)	Gross returns* (Rs/ha)
	Toria	Gobhi sarson		
1. Pure Toria (30 cm)	18.83	-	18.83	7814.45
2. Pure G. sarson (30 cm)	-	18.88	18.88	7835.20
3. Toria + G.sarson (1:1 ratio - 22.5 cm)	13.38	11.56	24.94	10350.10
4. Toria (30 cm) + G.sarson across sowing (30 cm rows)	16.77	10.31	27.08	11238.20
5. Toria followed by transplanting of G.sarson	19.10	9.75	28.85	11972.75
6. Transplanting of G.sarson as pure crop	-	11.01	11.01	4569.15

* Toria and Gobhi sarson @ Rs. 415.00/q (support price)

(iv) Intercropping with wheat: Rapeseed and mustard are preferred to be cultivated as pure crops in line sowing, as compared with mixed cropping along with wheat. In this practice, line sowing of 9 rows of wheat + one row of mustard can be done. The package of practices are the same as the one recommended for pure crop of wheat. Varieties PR 43, Kranti and Vardan had better performance over others, Table 20.

(v) Intercropping with gram: Under rainfed conditions, growing of one row of mustard after three rows of gram gives higher monetary returns. Nitrogen can be applied in mustard rows as per the recommendations made for mustard crop, Table 21.

(vi) Intercropping with potato: This is remunerative than pure crop of potato, Table 22. In this method, three ridges are planted with potato and the 4th ridge is left for mustard sowing. The seed rate for potato is kept equivalent to that of pure crop, and mustard is given the first irrigation after earthing of potato. The subsequent irrigations to potato are given

Table 20. Intercropping of wheat and mustard pooled over two years.

Treatments	Seed yield (q/ha) Wheat	Seed yield (q/ha) Mustard	Seed yield equivalents of wheat 1986-87	Seed yield equivalents of wheat 1987-88	Net returns (Rs/ha)
1. Pure wheat	44.55	-	31.11	52.00	4312.00
2. 9 rows of wheat + 1 row of mustard (Krishna)	34.73	1.62	39.63	38.59	3360.00
3. 9 rows of wheat + 1 row of mustard (Kranti)	41.81	1.64	38.69	49.53	4231.00
4. 9 rows of wheat + 1 row of mustard (Vardan)	40.00	1.45	41.16	46.01	4077.00
5. 9 rows of wheat + 1 row of mustard (PR-43)	41.81	1.64	40.54	54.54	4821.00
6. Wheat + mustard (seed mixture)	33.62	2.40	37.16	43.05	3542.00

Table 21. Intercropping of gram and mustard, pooled over two years

Treatments	Seed yield (q/ha) Gram	Seed yield (q/ha) Mustard	Seed yield equivalent of gram (q/ha)	Net returns (Rs/ha)
1. Pure gram	13.2	-	13.2	1209
2. Pure mustard	-	12.1	18.9	2226
3. Gram + mustard (3:1)	8.7	6.8	19.4	2690
4. Gram + mustard (4:1)	8.0	5.4	16.5	1895
5. Paired planting of gram and mustard	5.3	9.5	19.9	2560

Table 22. Studies on mustard and potato intercropping, pooled over two years.

Treatments	Yield (q/ha) Potato	Yield (q/ha) Mustard	Net returns (Rs/ha)
1. Pure potato (50 cm x 20 cm)	238.0	-	6760
2. Potato by border ridge technique (50 cm x 15 cm) + 1 mustard row in place of 4 rows of potato	214.2	5.2	7587
3. Pure mustard (45 cm x 15 cm)	-	16.1	5273

after closing furrows on both sides of the ridges on which mustard is planted.

10. Cropping sequence

In case of Toria which is grown as a catch crop, the farmers are anxious to have a variety which can mature about two weeks earlier than the existing variety under cultivation and which has higher yield potential. Particularly in maize-Toria-wheat rotation, early varieties of Toria fit well. Recently, with the development of short duration paddy varieties, Toria has also been introduced in paddy-Toria-sugarcane rotation. Mustard is usually taken as a full season crop after maize, rice, pearl millet or black gram. Besides, black gram-Toria-wheat sequence has also been found to be remunerative.

11. Harvesting stage

Harvesting of these crops at the stage when 75% of the pods turn yellow gives more yield and losses due to shattering are minimum, Table 23.

Table 23. Effect of stage of harvesting on Toria, pooled over two years.

Stage of harvesting	Seed yield (q/ha)	Decrease below (2) %
(1) Green pod stage	14.8	-25.2
(2) Yellow pod stage	19.8	-
(3) Complete maturity	16.9	-14.6

Possible Strategies For Increasing Production

1. The use of improved varieties, seeds and time-bound program for varietal replacement.
2. Planting as pure crops at the right time and identification of suitable plant types for mixed cropping.
3. Cultivation of Toria and mustard with autumn-planted sugarcane.
4. Introduction of these crops in suitable cropping systems.
5. Adoption of remunerative intercropping systems.
6. Use of optimum fertilizer dose.
7. Establishment of optimum plant stand.
8. Adoption of suitable crop protection measures.
9. Replacement of wheat area, with limited irrigation facilities, with mustard.
10. Extensive on-farm trials and field demonstrations.
11. Development of low input technology to serve the need of marginal and sub-marginal farmers.

DISEASE PROBLEMS IN BRASSICAS AND RESEARCH ACTIVITIES AT PANTNAGAR

S.J. Kolte, R.P. Awasthi and Vishwanath

Abstract

Research activities on management of seedling blights, Alternaria blight (AB), white rust (WR) and downy mildew (DM) diseases of rapeseed-mustard are highlighted. Tolerance to AB in *Brassica carinata*, *B. napus*, *B. alba* and in some cultures of cultivated *B. juncea*, has been established to be characterized by reduced infection rate suggesting its race-nonspecific nature against different races of most predominant causal fungus, *Alternaria brassicae*. However, resistance to WR in the above crop species appears to be race-specific as some of these (*B. juncea* exotic series) are immune or highly resistant to *Albugo candida* as against the highly susceptible reaction of some others as cultivated *B. juncea* cultures. This suggests the occurrence of races in *A. candida* also.

Until a break-through in breeding high yielding agronomically acceptable disease resistant cultivars is made, the diseased control strategy depends on the integrated use of early maturing and disease escaping or tolerant cultivars and on chemical control. Superiority of Iprodione to Dithiocarbamates in controlling AB is established, whereas the effectiveness of the use of mixture of Metalaxyl + Mancozeb in the control of WR and DM is confirmed.

Pathological research in respect of rapeseed-mustard crops is being carried out at Pantnagar with an overall objective of finding out disease resistant or tolerant cultivars or germplasm among the indigenously available materials or from the exotic *Brassica* species. In addition to this, assessment of yield losses due to diseases under different agricultural situations, variability in pathogens, and uses of cultural and chemical measures, also form part of the research activities for providing some basic information in devising integrated control strategy for management of the diseases of economic importance.

Seedling blights, Alternaria blight (AB), white rust (WR), downy mildew (DM), sclerotinia rot, powdery mildew, bacterial rot and phyllody are the important disease problems in India (1). Part of the information generated through research activities at Pantnagar has been presented in (2). Additional information obtained during the last two years period, i.e., 1986-1988, is given below:

A. Seedling Blights

Toria and mustard crops have been found to be affected by seedling diseases in the range of 1-3% under field conditions. The disease incidence may go beyond 15% when these crops are grown in rotation with sugarcane. Affected seedlings show distinct symptoms of collar rot, wilting, root and stem rots. Isolations from the disease seedlings may yield the growth of *Sclerotium rolfsii*, *Rhizoctonia solani* and *Fusarium oxysporum*. Though resistant to other important diseases, *Brassica alba*, has been found to be susceptible to *S. rolfsii* as compared to *B. campestris*, *B. carinata*, *B. juncea*, *B. napus* and *B. nigra* under natural conditions, Table 1.

Seed treatment with Mancozeb, Thiram, Captafol (each @ 0.2%) has been found to protect the plants against infection from *S. rolfsii* and *F. oxysporum*, whereas seed treatment with Thiophanate methyl (0.2%) or Carbendazim (0.2%) has been observed to be more effective for the control of seedling infection caused by *R. solani*.

Table 1. **Natural occurrence of collar rot of rapeseed-mustard caused by *sclerotium rolfsii***

Crop species	Incidence of collar rot (%)*
Brassica alba	10.53
B. campestris var Toria cv. PT 303	2.80
B. campestris var yellow sarson cv. 151	1.30
B. carinata	1.10
B. juncea cv. varuna	1.80
B. napus	0.90
B. nigra	1.90

*Average of two years observations at Pantnagar in field previously grown with soybeans.

B. *alternaria Blight*

The quantitative loss in yield due to AB has been estimated to be 35-46% (4). Pods harvested from affected plants show shrivelled, shrunken and discolored seeds. Four species of *Alternaria* i.e., *A. brassicae,* A. brassicicola, A. raphani and *A. alternata* have been found to be associated with the disease under field conditions, though leaf and pod infection due to *A. brassicae* is most common. When two or more species occur together on the same leaf, it may, in practice, be difficult to distinguish them by macroscopic symptoms. Thus, correct identification of the pathogen depends on the isolation and microscopic studies.

1. Variability in *A. brassicae*

i. Natural occurrence of different strains: The most predominant *Alternaria* species i.e., *A. brassicae* has been found to exist as three distinct isolates; A, C, and D which have been proved, for the first time, to be three distinct strains or races of *A. brassicae* under Indian conditions. It is observed that *A. brassicae* isolate C is more prevalent (65%) than A (47.3%) and D (42.9%) isolates. *A. raphani* infects more readily *B. alba* and *B. juncea* cv. Exotic to the extent of 65-70%. The prevalence of *A. alternata* is noted only to the extent of 2-17% but when it interacts with *A. brassicae* and *A. raphani* it increases the susceptibility of *Brassica* species to the disease.

ii. Variability in growth characters: The three isolates of *A. brassicae* show distinct variability with respect to their growth and colony characters on media, size and shape of conidia, sporulation and chlamydospore formation. The best sporulating is isolate C. Asparagine, as a source of nitrogen, does not support the growth of any of the isolates of *A. brassicae* which otherwise supports good growth of *A. raphani* and *A. alternata*. *A. brassicae* isolate A could usually germinate from the middle cell and isolate C from the upper most cell in comparison with the germination of spore by formation of elongation of the spore beak itself in respect of isolate D. Isolate C has been observed to produce secondary conidia as against the absence of such conidia in the case of isolates A and D.

It has been distinctly observed that isolate D shows brownish-grey colony on Sabourd's agar (SA) medium which is quite distinct from white cottony growth of isolates A and C. Thus the SA medium can be used to identify the strains of *A. brassicae*. The formation of chlamydospores has been observed in the case of *A. raphani* and *A. brassicae* isolate A as against the absence of the chlamydospores in the case of isolates C & D.

iii. Variability in degree of virulence: Based on degree of defoliation effect through artificial infection, *A. brassicae* isolate C is more virulent on indigenously cultivated *B. juncea* and *B. campestris* cultivars, whereas isolate D is more virulent on *B. napus* cv.2, Table 2. On *B. carinata*, the three isolates of *A. brassicae* produce three kinds of distinct spots thus enabling the use of *B. carinata* as indicatr host for identification of races of *A. brassicae*. *Similarly* B. alba, B. juncea cv. exotic, and *B. napus* cv. EA are found to be indicator hosts for identification of *A. raphani*.

Table 2. Degree of Virulence* of *A. brassicae* isolates, *A. raphani* and *A. alternata* on different *Brassica* species

Brassica	*A. brassicae* isolates			*A. raphani*	*A. alternata*
	A	C	D	E	B
B. alba	-	-	-	+	-
B. carinata cv GS	-	+	-	-	-
B. carinata cv RS	+				
B. napus cv EA	-	-	-	+	-
B. napus cv Regent	-	+	-	-	-
B. napus cv 1	+	-	-	-	-
B. napus cv 2	-	-	+	-	-
B. juncea cv Varuna	-	+	-	-	-
B. juncea cv Exotic	+	-	-	+	-
B. campestris cv YST 15	+	+	-	-	-

*+indicates highest degree of virulence of respective isolate or species.
-indicates low to moderate virulence.

2. Management

i. Host Resistance in Commonly Cultivated *Brassica* species: Several varieties and germplasm lines of cultivated forms of *B. campestris* (Toria or sarson) and *B. juncea* (mustard) have been screened both under naturally and artificially infected conditions. These show differences in the degree of their susceptibility; some being tolerant, but the possibility of the existence of major gene sources of resistance is lacking. The level of resistance/ tolerance is not sufficient enough to be used as transferable sources for incorporation of resistance/ tolerance in the more desirable, agronomically acceptable but susceptible cultivars. Some types such as yellow sarson "Type 6" and mustard "PHR 1" have the potential to be used as such, following selection procedure. It has been observed that young plants of less than 30 days are less susceptible to the disease and the susceptibility increases as the plant age increases.

ii. Host Resistance in Exotic *Brassica* Species: Among the exotic *Brassica* species, *B. alba* and *B. napus* cv EA show resistance to the most prevalent *A. brassicae* isolates. But the problem of using their resistance becomes complicated as these are susceptible to *A. raphani* as discussed above. The possibility of using these species in hybridization program poses a danger of increasing susceptibility of the cross-bred material to *A. raphani*.

Based on the components of resistance, like relatively small size of spots, less defoliation, longer incubation, latent periods and reduced sporulation /lesion, it is consistently observed in the present studies that *B. carinata* is more resistant to *A. brassicae, A. raphani* and *A. alternata* as compared to other species, Table 3 and the nature of resistance appears to be non-specific i.e, horizontal type characterized by reduced infection rate. The apparent infection rate in the case of *B. carinata* has been observed to be 0.154-0.267 as against very high infection rate of 0.763 in the case of *B. juncea* cv. Varuna and *B. campestris* var yellow sarson cv T 151. On the basis of the yield data, *B. carinata* has a potential of yielding to the extent of 24 q/ha as against 7-9 q/ha in the case of *B. juncea* and *B. campestris* cultivars under Alternaria-affected conditions. *B. carinata* has never been found to be affected by WR, DMand PM diseases when cultivars of commonly cultivated *B. juncea* and *B. campestris* show very high degrees of severity of these diseases under similar conditions.

Table 3. Incubation (I) and latent (L) periods in days in respect of *A. brassicae* isolates (A,C,D), *A. raphani* (E) and *A. alternata* (B) on surfaces of leaves of some oleiferous *Brassica* species.

Crop species	*A. brassicae* isolates						*A. raphani*		*A. alternata*	
	A		C		D		E		B	
	I	L	I	L	I	L	I	L	I	L
B. alba	14	22	12	17	12	18	7	11	15	22
B. carinata cv 6S	12	16	11	16	11	16	12	16	13	23
B. napus cv 1	14	21	13	16	13	16	9	12	13	20
B. napus cv EA	13	17	13	19	13	17	13	16	13	24
B. napus cv Regent	9	13	13	17	12	15	13	16	14	24
B. juncea cv Varuna	6	9	7	9	6	8	9	13	9	14
B. juncea cv PHR	11	14	14	13	8	10	8	10	9	13
B. campestris cv YST 151	5	7	6	9	7	11	10	13	11	15

Note : Data were obtained through artificial infection keeping the inoculated leaves in moist chambers.

iii. Control Through Disease Escape: Early maturing cultivars, if planted during the last week of September and the first week of October, have been found to be escaping the severe development of AB, WR and DM diseases. Fortunately, in the important crop species, some early varieties have been identified. These are Toria types: M-27, TS-29, PT-83, Bhavani and RAU-1; mustard types: PR-36, PR-1D, RLM 51; yellow sarson types: YSB-9, RAUS-3 and PYS-6. It is suggested that the efforts should be made to identify such varieties for cultivation.

iv. Chemical Control: Alternaria blight can be controlled by spraying some fungicides like Mancozeb, Captafol or Ziram @ 0.2%, (Table 4). The results of the field trials conducted over the last three crop seasons (1985-1988) at Pantnagar revealed that Iprodione is superior to Mancozeb, Ziram and Captafol and can result in 86% increase in yield as compared to unsprayed plants. But Iprodione is not effective against WR+ DM. Spray of mixture of Metalaxyl + Mancozeb (Ridomil MZ) @ 0.2% is found to be effective in the control of WR, DM and AB diseases provided the sprays are made to control the staghead phase at 3.9-4.0 stages of the crop growth.

Table 4. Effect of some fungicides on yield of toria at Pantnagar, 1985-88.

Fungicide	Yield (q/ha)			Yield increase Over check (%)
	85-86	86-87	87-88	
Iprodione @ 0.2	15.73	15.62	23.74	86.78
Mancozeb @ 0.2	13.33	12.30	21.01	57.92
Captafol @ 0.2	12.26	11.92	19.75	50.81
Ziram @ 0.2	13.39	11.00	-	23.88
Metalaxyl + Mancozeb (Ridomil MZ)*	13.39	10.99	17.75	42.68
Thiophanate Methyl @ 0.05	9.19	9.85	-	-3.25
Boric acid powder @ 0.53	11.53	12.97	17.15	40.75
Check: No spray	8.39	8.83	12.30	-
CD at 5%	2.44	2.16	3.94	-

*Concentration used in 1986-86 and 1985-87 was 0.2% and in 1987-88 it was 0.5%.

C. White Rust and Downy Mildew

Based on the staghead phase severity, the losses in yield due to WR + DM infection have been estimated to be in the range of 17-37% (2). Both diseases, unlike AB, are more dependent on the favourable weather conditions as described earlier (2). Reduced period of sunlight (2-6 h/day) and rainfall upto 161 mm during the flowering period favour the severe occurrence of the stagheads in the winter rabi crop season (3).

Results of the work done during the past two years period are briefly given below.

1. Variability in *Albugo candida*

There are indications that there are races of *A. candida*. This is evident because of the differences in the pustule size and shape and immune reaction of some exotic *Brassica* species (BEC series) as against susceptible reactions of commonly cultivated *B. juncea* cultivars like Varuna etc., (Table 5). However, detailed studies on characterization of races through differential host reaction need to be carried out. There are problems and practical difficulties in the development of artificial infection and easy use of the screening techniques.

2. Management

i. Host resistance/tolerance: Among the cultivated *Brassica* species, *B. juncea* cv "YRT 3" and *B. campestris* cv "PYS 6" have been observed to show resistance/ tolerance reaction to WR + DM under field conditions. Some of the *Brassica* species like *B. alba*, *B. carinata*, *B. napus* and *B. juncea* cv Exotic have never been found to be affected with these diseases. The nature of resistance appears to be race-specific which needs further study for their effective utilization in the breeding program.

ii. Control through disease escape: Use of early maturing cultivars as discussed under AB can be of practical importance to minimize the losses caused by WR + DM diseases.

Table 5. Reaction of some exotic *B. juncea* cultures to *Alternaria* blight (AB) and white rust (WR)*

Culture	AB index on leaf (%)	AB index on pods (%)	WR index on leaf (%)
BEC 107	50-60	17-28	0-10
BEC 109	60-75	22-23	0-0
BEC 111	40-75	9-40	0-0
BEC 112	48-60	25-45	0-10
BEC 115	30-58	12-28	0-0
BEC 127	30-68	16-32	0-0
BEC 138	30-52	9-24	0-0
BEC 152	30-50	9-11	0-0
BEC 142	58-65	9-22	0-0
BEC 164	58-64	9-17	0-0
K 41729	36-58	9-22	0-3
Varuna	60-84	36-40	60-78
Yellow sarson "T 151"	80-90	50-60	20-40

*Data based on average of two crop seasons (1986-87 & 1987-88) at Pantanager.

iii. Chemical control: As in the previous years, seed treatment with Apron 35 SD @ 0.2% concentration is found to be effective in checking cotyledonary infection of downy mildew in both Toria and mustard. But seed treatment alone is not effective to control the staghead phase of WR + DM. Hence, spray of mixture of Metalaxyl + Mancozeb is required to control the staghead phase, (Table 4).

D. Other Diseases

Research on disease control measures in respect of bacterial rot, and *Scolerotinia* rot, and phyllody needs to be initiated as their occurrence is seen to be increasing under the changing cropping pattern.

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EFFECT OF SOME EPIDEMIOLOGICAL FACTORS ON OCCURRENCE AND SEVERITY OF ALTERNARIA BLIGHT OF RAPESEED AND MUSTARD

R.P. Awasthi and S.J. Kolte

Abstract

Correlations between weather factors and severity of *Alternaria blight* (AB) on rapeseed yellow sarson cv T-151 and mustard cv Varuna (T-59) were established based on the data obtained over a seven-year crop period (1980-1987). Relative humidity (>67%), total rainy days (>6), rainfall (>70mm) and minimum temperature (7-10°C) concomitant with maximum temperature (20-23°C) were found to be positively correlated (r = 0.511-0.805) with AB severity on leaves, whereas the former two factors only showed significant positive correlation (r = 0.758 and 0.962) for the spread of pod infection. Relative humidity below 67% was less conducive for a severe development of the disease. The prediction equations for AB severity were derived by regression analysis. The severity of AB was found to be favoured by the above weather factors beyond 30 days of age and the increase in age was positively correlated (r = 0.777-0.980) with the increase in the susceptibility of the crop; the maximum leaf disease severity being at rosette to flowering stage of the crop.

Alternaria blight of rapeseed-mustard is a disease of economic importance in India (2). It occurs quite regularly every year during the crop season (October to March) resulting in 35-46% yield loss (3). In certain cultivars of yellow sarson, the loss in yield may go to the extent of 70%. Though effects of fungicidal sprays, planting dates, etc. have been studied on control of the disease, basic information with respect to epidemiological factors on occurrence and severity of the disease have not been well documented. The present investigation deals with the study of some weather factors and the effect of plant age on the development of the disease. The results obtained over seven-year crop season (1980-1987) are presented herein.

Materials and Methods

1. Growing of the Brassicaspecies and the field layout

Two susceptible *Brassica* species viz., *B. juncea* cv T-59 (Varuna) and *B. campestris* var yellow sarson cv T-151 along with four other exotic *Brassica* species (*B. alba*, *B. carinata*, *B. juncea* and *B. napus*) were grown at the Crop Research Centre, Pantnagar, in seven consecutive crop seasons (from 1980-81 to 1986-87). Randomized block design using 3 x 4 m plot size with four replications was followed each year. The sowing was done in rows spaced at 40 cm distance keeping plant-to-plant spacing at 15 cm. A distance of 1.5 m was maintained between plots and replications. Nitrogen @ 100 kg/ha was applied along with phosphorus (40 kg/ha) and potash (40 kg/ha). The sowing was done in the middle of October in 1982 and 1986 and in the last week of October in the other five crop seasons. Other agronomic practices including weeding, irrigation, etc. were followed whenever needed to maintain the proper growth. The crop was protected against aphid infestation by a spray of Metasystox @ 0.1%

2. Recording the AB severity

Average disease severity on leaf and pod was taken separately at weekly interval using 0-5 rating scale which is given in Table 1.

Twenty five leaves/pods were collected randomly from each plot and rated. The disease index was then calculated using the formula:

Disease index (%) =

$$\frac{\text{Sum of all numerical ratings}}{25 \times 5} \times 100$$

Table 1. Rating scale used to measure AB disease severity.

	Area covered by spots (%)	
Rating Scale	Leaf	Pod
0	No symptoms	No symptoms
1	1-10	1-10
2	11-25	11-20
3	26-50	21-30
4	51-75	31-50
5	> 75	> 50

3. Studying the relationship of weather factors associated with the development of AB

Final severity of AB on middle leaf (on the main stem) referred to as Y_1 and on pod (on the main raceme) referred to as Y_2 in different crop seasons were pooled together cultivar-wise and correlated with the meteorological factors viz., mean maximum (x_1) and mean minimum (x_2) temperatures, per cent relative humidity (x_3), total rainfall (x_4), total number of rainy days (x_5) and sunshine hours/day (x_6) recorded for the period between the 5th and the 15th week after sowing for leaf infection and for the period between the 10th and the 18th week after sowing for pod infection. The correlation coefficient (r) between the average disease index and weather factors was computed as per the method given by (5). Similarly the predicted mean disease severity index "y" equation ($Y = a + b_1 x_1 + b_2 x_2 + \ldots\ldots + b_6 x_6$) was derived by multiple regression analysis, where "y" denotes the predicted AB severity on leaf (Y_1) and on pod (Y_2); "a" denotes the intercept and "b_1" to "b_6" denote partial regression coefficients for x_1 to x_6 weather factors. Significance of correlation coefficient (r) and coefficient of determination (R^2) was followed at 5% level of probability.

4. Computation of apparent infection Rate

Apparent infection rates (ir) were calculated from the AB severity index at different week times of the plant growth using the formula given by:

$$ir = \frac{2.3}{t_2 - t_1} \log10 \frac{x_2(1 - x_1)}{x_1(1 - x_2)}$$

where ir = apparent infection rate in non-logarithmic phase; $x_1$disease index at initial week time t_1 and x_2 = disease index at subsequent week times t_2 . The apparent infection rates were further used to assess the maximum and minimum infection periods with respect to each crop species in relation to age.

Results and Discussion

In order to understand the effect of weather factors on the most commonly grown susceptible cultivars of mustard (Varuna) and yellow sarson (T-151), the results obtained with respect to these two only are described below. The results on other *Brassica* species which are not cultivated in India will be described in a separate research article.

1. Leaf infection severity of AB on yellow sarson and mustard

Significant positive correlations (r = 0.764 to 0.804) were observed between AB severity index on the yellow sarson leaf and relative humidity (RH), total rainfall (RF) and minimum temperature (Mi Temp). Similar results were obtained with respect to AB severity on leaf of the mustard (r = 0.725 to 0.805), but the "r" values in respect of the RH and RF factors were non-significant, Table 1. The values of the R^2 values revealed that a combined effect of RH, RF and Mi temp accounted for more than 98%

variation in AB severity on leaves of both yellow sarson and mustard, (Table 2). The AB severity prediction equations as derived in the present studies for leaf infection phase in respect of yellow sarson and mustard are given below:

i. AB leaf infection severity on yellow sarson:

$$(Y_1) = -49.95 + (8.28\ X_2) + (0.12\ X_3) + (0.85\ X_4) + (-0.95\ X_5) + (1.13\ X_6).$$

ii. AB leaf infection severity on mustard:

$$(Y_1) = 63.78 + (10.80\ X_2) + (-2.38\ X_3) + (1.19\ X_4) + (-2.58\ X_5) + (3.64\ X_6).$$

The crops were found to be susceptible to leaf infection phase during rosette to flowering stage when the maximum temperature (Max Temp) ranged between 20 and 23°C and the Mi Temp was in the range of 7-10°C with average RH of 67-73% concomitant with total RF of 70mm and sunshine period (SP) of 5-7 h/day, (Fig. 1). Less than 67% RH and less than 7°C Mi Temp, irrespective of other favourable factors, did not result in severe occurrence of the leaf infection phase.

Table 1. Relationship of weather factors associated with AB severity on leaves of yellow sarson and mustard, as measured by correlation coefficient (r).

Brassica species	Max. Temp. (°C) x_1	Min. Temp. (°C) x_2	R.H. (%) x_3	Total rainfall (mm) x_4	Total rainy days x_5	Sunshine (h/day) x_6
B. campestris var. yellow sarson cv T-151	0.190	0.764*	0.804*	0.784*	0.527	-0.608
B. juncea cv T-59	0.302	0.805*	0.706	0.725	0.511	-0.582

*Significant at 5% level of probability.

Table 2. R^2 values of different stepwise multiple regression equations for prediction of AB severity on leaves (Y_1) of yellow sarson and mustard.

Stepwise predication equations	R^2
B. campestris var yellow sarson cv T-151:	
1. $Y_1 = a + b_3 x_3$	0.65*
2. $Y_1 = a + b_3 x_3 + b_2 x_2$	0.79*
3. $Y_1 = a + b_3 x_3 + b_2 x_2 + b_4 x_4$	0.99*
4. $Y_1 = a + b_3 x_3 + b_2 x_2 + b_4 x_4 + b_5 x_5$	0.99*
5. $Y_1 = a + b_3 x_3 + b_2 x_2 + b_4 x_4 + b_5 x_5 + b_6 x_6$	0.99*
B. juncea cv T-59:	
6. $Y_1 = a + b_2 x_2$	0.65*
7. $Y_1 = a + b_2 x_2 + b_4 x_4$	0.98*
8. $Y_1 = a + b_2 x_2 + b_4 x_4 + b_3 x_3$	0.98*
9. $Y_1 = a + b_2 x_2 + b_4 x_4 + b_3 x_3 + b_5 x_5$	0.99*
10. $Y_1 = a + b_2 x_2 + b_4 x_4 + b_3 x_3 + b_5 x_5 + b_6 x_6$	0.99*

*Significant at 5%.

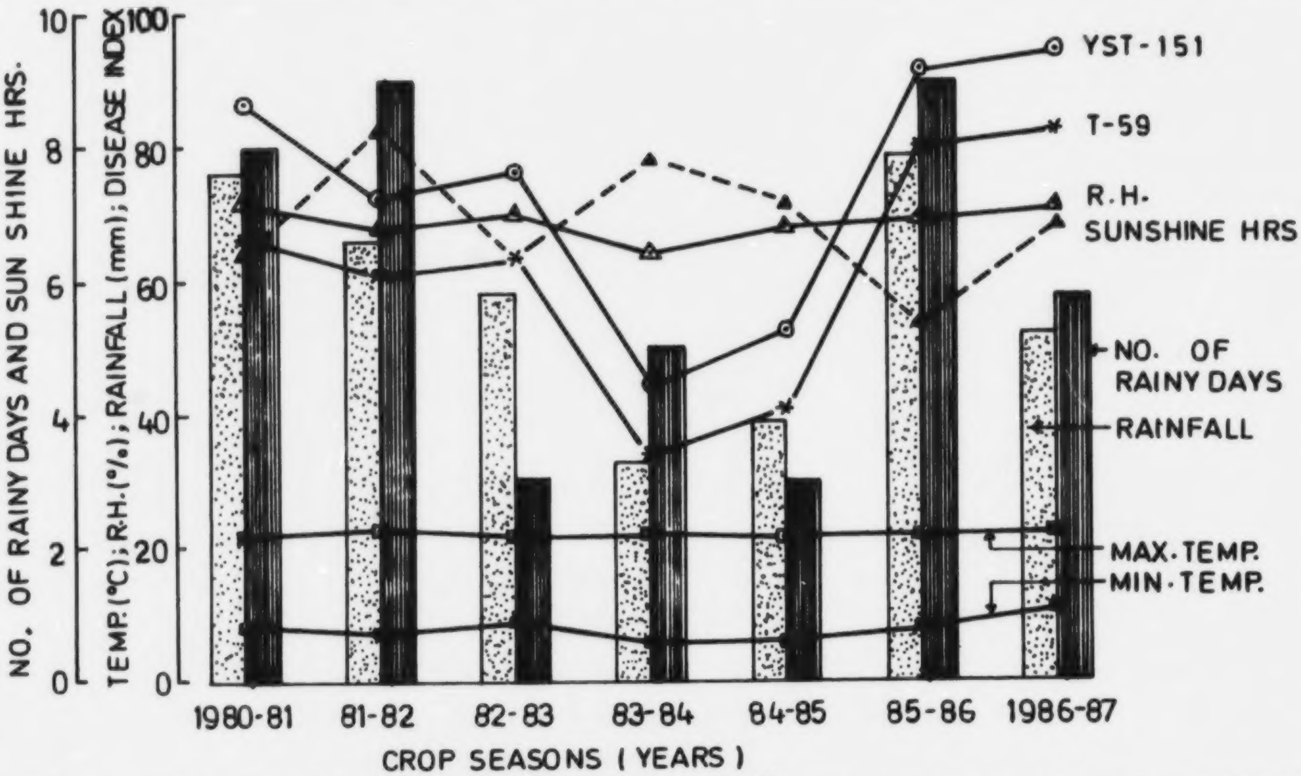


Fig. 1 AVERAGE WEATHER FACTORS FROM 5-15th WEEK AFTER SOWING ASSOCIATED WITH DISEASE SEVERITY ON LEAF OF T-59 AND YST-151 UNDER DIFFERENT CROP SEASONS (1980-81 TO 1986-87).

2. Pod infection severity of AB on yellow sarson and mustard

Total rainy days (TRD) (r = 0.962 and 0.758, respectively) showed significant positive correlation with AB development on pods of yellow sarson and mustard, (Table 3). When TRD was included in the prediction equation for yellow sarson, the value of R^2 was more than 93%, (Table 4), indicating, there by, that AB severity on yellow sarson pods was mainly influenced by the frequency of TRD during the time from flowering to yellow pod stage of the crop. But in the case of mustard, R_2 values for RH showed maximum (57%) variation suggesting, thereby, the importance of RH factor in pod infection of mustard. Thus it is concluded that high frequency of TRD and RH appear to be more important factors for the spread of AB infection on pods, (Fig. 2). Similar results have been reported under the Punjab (1) and West Bengal (4) conditions.

Table 3. Relationship of weather factors associated with AB severity on pods of yellow sarson and mustard as measured by correlation coefficient (r).

Brassica species	Max. Temp. (^0C) x_1	Min. Temp. (^0C) x_2	R.H. (%) x_3	Total rainfall (mm) x_4	Total rainy days x_5	Sunshine (h/day) x_6
B. campestris var. yellow sarson cv T-151	-0.635	-0.001	0.645	0.590	0.962*	-0.324
B. juncea cv T-59	-0.387	0.334	0.758*	0.144	0.670	-0.511

*Significant at 5%.

Table 4. R^2 values of different stepwise multiple regression equations for prediction of AB severity on pods (Y_2) of yellow sarson and mustard.

Stepwise predication equations	R^2
B. campestris var yellow sarson cv T-151:	
1. $Y_2 = a + b_5 x_5$	0.93*
2. $Y_2 = a + b_5 x_5 + b_1 x_1$	0.94*
3. $Y_2 = a + b_5 x_5 + b_1 x_1 + b_6 x_6$	0.98*
B. juncea cv T-59	
4. $Y_2 = a + b_3 x_3$	0.57*
5. $Y_2 = a + b_3 x_3 + b_1 x_1$	0.66*
6. $Y_2 = a + b_3 x_3 + b_1 x_1 + b_5 x_5$	0.91*
7. $Y_2 = a + b_3 x_3 + b_1 x_1 + b_5 x_5 + b_2 x_2$	0.99*
8. $Y_2 = a + b_3 x_3 + b_1 x_1 + b_5 x_5 + b_2 x_2 + b_6 x_6$	0.99*

*Significant at 5%.

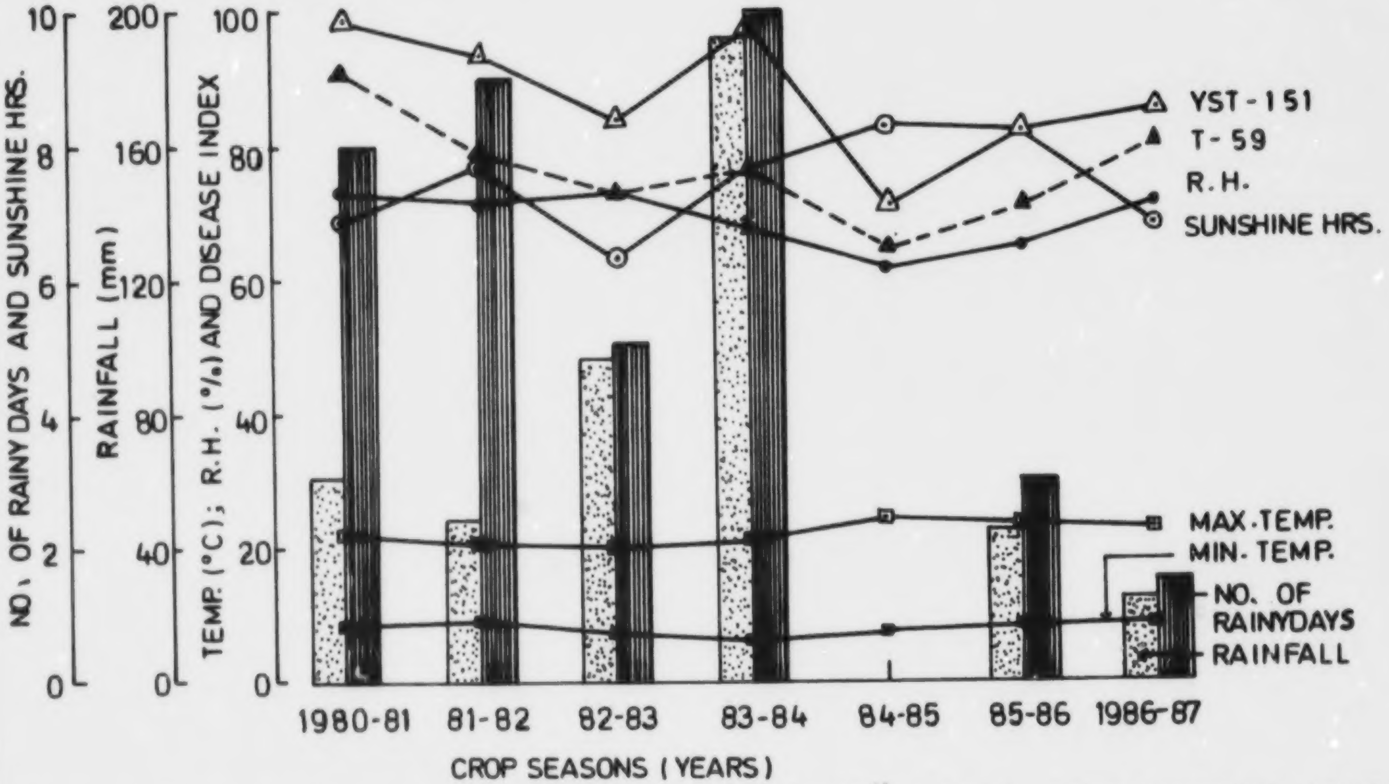
Keeping other factors constant, sunshine period (h/day) showed negative correlation with AB severity in the present study. The prediction equation for pod infection in respect of yellow sarson and mustard are given below.

i. AB infection severity on yellow sarson pod:

$$(Y_2) = 16.18 + (3.75 X_1) + (3.52 X_5) + (-4.23 X_6).$$

ii. AB infection severity on mustard pod:

$$(Y_2) = - 316.24 + (10.84 X_1) + -4,29 X_2) + (2,76 X_3) + (2.38 X_5) + (-2.62 X_6).$$



Fig·2 AVERAGE WEATHER FACTORS FROM 10 TO 18th WEEK AFTER SOWING ASSOCIATED WITH DISEASE SEVERITY ON POD OF T-59 AND YST-151 UNDER DIFFERENT CROP SEASONS (1980-81 TO 1986-87).

3. Relationship between age of the plant and susceptiblity to AB

Plant age showed high degree of singificant positive correlation with AB severity on leaf (r = 0.777 to 0.850) as well as on pod (r = 0.980 to 0.938). Maximum apparent infection rate (ir = 0.763) on leaf was observed between 10 and 12 weeks after sowing in the case of yellow sarson and mustard, indicating thereby the maximum susceptibility of the plants, beyond 60-90 days after sowing. Young plants, less than 30 days of age, did not show development of symptoms on the leaf under field conditions.

This suggests that with increase in the age beyond 30 days, the susceptiblity of the crop increases and becomes at its peak at 60-90 days. This information, thus, becomes a useful guide for time of application of the fungicides for maximum efficacy of the fungicidal control.

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PROBLEMS OF INSECT PESTS IN BRASSICAS AND RESEARCH WORK AT PANTNAGAR

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Abstract

Rapeseed/mustard is attacked by about 38 insect pests, out of which mustard aphid, *Lipaphis erysimi* (Kaltenbach), mustard sawfly, *Athalia proxima* (klug), painted bug *Bagrada cruciferarum* (Kirk), leaf miner, *Chromatomyia horticola* and Bihar hairy caterpillar, *Spilosoma obliqua* (walker) are of major concern. Among these, mustard aphid is a national pest responsible for causing 54.2% yield loss on country basis. The avoidable losses in *Brassica campestris* var. Toria and Sarson, *B. juncea* and *B. napus* due to insect pests have been estimated to be 53.60, 77.96, 69.38 and 85.25%, respectively.

Food and oviposition preferences by sawfly and its development, pupation and basking behaviour have been discussed. Similarly, food preference, plant part preference and screening techniques like growth and development, honey dew and cafeteria tests have been discussed for aphid. Mechansim of resistance in RW-2--2, RW 15-6 and B-85 (glossy) have been discussed based on biochemical and physiological characters.

Management of sawfly and aphid by the use of insecticides has been elaborated and effect of insecticides on aphid population, oil and protein contents of plant and coccinellid predator have been presented.

Among oilseeds, rapeseed-mustard occupies second place both in area and production in the country covering 20.8% (3,879,000 ha) area and sharing 22.8% (2,641,000 tons) in oilseed production. It contributes 25.8% of the total vegetable oils in the country with production of 936,000 tonnes. India contributes 16% of the total production of rapeseed-mustard in the world. Inspite of this satisfactory contribution, the per hectare yield is only 6.94 quintals as against the world average of 12.62 quintals/ha, though we are better off than some other countries. The rapeseed-mustard production was 4.89 and 30.58 quintals/ha in Ethiopia and the Netherlands, respectively.

In India, one of the major constraints in the production of rapeseed-mustard is the ravage caused by insect pests. Among 38 attacking rapeseed species, mustard aphid (*Lipaphis erysimi* Kaltenbach), mustard painted but, (*Bagrada cruciferarum* Kirk), leaf miner (*Chromatomyia horticola* Goureau) and Bihar hairy caterpillar (*Spilosoma obliqua* Walker) are the major ones. The details of these insects with others of minor importance and the new insects recorded at Pantnagar are given in Tables 1 and 2.

Extent of Losses

The losses caused by insect pest complex on rapeseed-mustard vary from 53.60 to 85.25% being highest on *Brassica napus* and lowest on Toria, Table 3. Avoidable losses are more in Punjab and less in U.P. (3). In other states the avoidable losses are found to be 43.48% in Bihar (10), 25-30% in Rajasthan (36) 5% in Karnataka (28) and 5800 MT in Gujarat (11). At Navgaon, Rajasthan, the avoidable losses observed were 44.13, 14.68 and 51.25% with aphid alone, sawfly and painted bug and entire pest complex respectively on Varuna while on Pusa Kalyani (mustard varieties) the losses were 62.5, 17.62 and 63.24%, respectively (4). In Faizabad (U.P.) the losses caused by insects, except aphid, were

22.23% in Toria, 28.8% in yellow sarson, 7.25% in rai (mustard) and 15.6% in gobhi sarson (*B. napus*) (4). The avoidable losses at Pantnagar are presented in Table 4.

Table 1. Insect complex on rapeseed/mustard

Common name/scientific name	Stage of damage		Nature of damage	Intensity of the pest at Pantnagar
	Crop	Pest		
A. Major pests				
Mustard aphid *Lipaphis erysimi* Kalt.	All stages	Nymph and adults	Sucking sap	Moderate/High
Mustard sawfly *Athalia proxima* Klug	Seedling	Grub	Defoliation	Moderate
Painted bug (*Bagrada cruciferarum* Kirk.	Seedling and Pod	Nymph and adults	Sucking sap	Trace
Leaf miner *Chromatomyia horticola*	Leaf	Later *maggots*	Mining leaf	- do -
Bihar hairy caterpillar *Spilosoma obliqua* W.	Early/ later	Caterpillar	Defoliation	Low
B. Minor Pests				
Flea beetle *Phyllotreta cruciferae*	Coty- *ledons*	Adult	Shot holes	- do -
Peach aphid *myzus persicae* Sulzer	All stages	Nymph/ adult	Sucking sap	Very low
Cabbage aphid *Brevicoryne brassicae* Linn.	- do -	- do -	- do -	Nil
Cotton aphid *Aphis gossypii* G.	- do -	- do -	- do -	Nil
Cabbage butterfly *Pieris brassicae* Linn.	Leaves	Caterpillar	Defoliation	Trace
Cabbage leaf Webber *Crocidolamia binotalis* Z.	Leaves/ pods	- do -	Webbing	- do -
Cabbage Semilooper *Plusia orichalcea*	Leaves	- do -	Defoliation	Low
Diamond back moth *Plutella xylostella* Linn.	- do -	- do -	- do -	Trace
Whitefly *Bemisia tabaci* Genn.	- do -	Nymph/ adult	Sucking sap	Nil
Cutworm *Agrotis segetum* D. & S.	Seedling	Caterpillar	Cuts germinating plants	Trace

Table 2. Some new insect pests on rapeseed-mustard at Pantnagar

Common name/scientific name	Stage of damage		Nature of damage	Intensity
	Crop	Pest		
Stemborer *Melamgogromyza cleome*	Stem	Maggot	Bores the stem	Trace
Banded flea beetle (to be identified)	Cotyledons	Adult	Making shot holes	Trace
Pantatomid bug (to be identified)	Seedling/ pod	Nymph and adults	Sucking sap	Low
Lygaeid but (to be identified)	Matured pods	Nymph and adults	Sucking seed content	Low
Curculionid beetle (to be identified)	30 days crop	Grub	Bores at cortical region	Trace

Table 3. Avoidable losses (%) caused by insects in Brassica crops (1986-87)

Places	Toria	Sarson	Mustard	Napus
Ludhiana (Punjab)	-	97.1	94.2	81.8
Pantnagar (U.P.)	80.03	37.20	38.73	-
Kanpur (U.P.)	27.18	96.95	73.14	-
Hissar (Haryana)	-	80.6	71.45	88.70
Mean	53.60	77.96	69.38	85.25

(AICORPO, 1987).

Table 4. Assessment of yield losses (%) due to insect pests at Pantnagar

	Percent loss in yield		
Varieties	1986-87	1987-88	Mean
Toria:			
PT-25	34.18	9.16	21.67
PT-30	30.96	16.67	23.81
PT-75	8.82	24.27	16.54
PT-303	19.12	13.72	16.42
PT-507 B	22.18	16.64	19.41
T-9	4.93	11.41	8.17
Mean	20.03	15.31	17.67
Mustard:			
Kranti	43.86	20.18	32.02
Krishna	44.77	7.89	26.33
PR-35	33.69	19.10	26.39
Varuna	32.62	14.49	23.55
Mean	38.73	15.41	27.07
Yellow sarson:			
PYS-6	34.94	13.24	24.09
YST-151	39.47	22.79	31.13
Mean	37.20	18.01	27.61

Mustard Sawfly

This is one of the important insects of rapeseed/mustard at seedling stage and causes 10-25% loss in yield under normal conditions but sometimes losses may be even 100% in severe attack. Sawfly appears in mid September and remains active till January with peak period of incidence during October-November and also higher during December particularly on late sown mustard crop.

The attack of this insect starts when seedlings are 2-3 weeks old. This stage of the crop is suitable for egg laying, but as the plant becomes older the preference for oviposition reduces. The four-week old crop is more damaged by this insect as compared to the eight-week old one.

Ovipositional preference

Ovipositional preference indicated that B. campestris Var. Toria, B. campestris Var. Dichotoma, B. campestris Var. Sarson, B. chinensis, B. rapa, B. juncea, B. rugosa and Seinebra pinnatifida are distinctly preferred over B. napus, B. oleracea Var. Botrytis, Raphanus sativus, Eruca sativa and Iberis aamara. No eggs were laid on Cherianthus cheiri and Tropaeolum majus. Both laboratory and field studies indicated that B. juncea, B. alba, B. nigra and Sinapis alba are more preferred by sawfly as compared to B. napus and B. carinata. Among the B. juncea, indigenous cultivars are more preferred, Table 5.

Table 5. Ovipositional preference of mustard sawfly

Host plant	Nature of leaf	Eggs laid 10 plants
Brassica juncea		
RC-781	Smooth	57.80
PR-15	Smooth	12.20
PR-18	Smooth	34.40
R-3245	Smooth	41.20
Varuna	Smooth	36.00
Blaze	Hairy	7.80
Matopolaska	Hairy	3.20
Lethbridge	Hairy	3.80
Stoke	Hairy	2.80
Domo	Hairy	13.00
Cultidoma	Smooth	21.60
Brassica napus	Smooth	4.60
Brassica rugosa FS-902	Intermediate	29.60
Brassica alba	Hairy	22.40
Brassica nigra	Hairy	7.60
Brassica tournifortii	Smooth	4.80
SE (Mean)		5.67
CD (5%)		15.84

This difference could be due to the hairyness of the leaf which acts as a barrier for oviposition in addition to some unknown biochemical and biophysical factors (20, 22a).

Feeding preference

Only the plants of family Cruciferae and Tropaeolaceae are accepted by grubs indicating the narrow host range of this insect was more on *B. campestris* var sarson, *B. rape, B. juncea* and *B. oleracea* var *capitata* and less on B. napus, B. carinata, Raphanus sativus, B. oleracea var botrytis, *B. oleracea* var gongyloides and least on *Iberis amara* and *Tropaeolum* sp. Among the exotic materials, *B. alba* is more preferred followed by porbiraya (*B. juncea*). *B. napus* as a whole, PC 1 and PC 2 (*B. carinata*) and *B. nigra* are least preferred (22).

Basking behaviour

Basking behaviour of grub indicates that larvae started coming out at 6.30 a.m. from cracks and crevices of soil and their maximum number reached during 10-10.30 a.m. At this stage larvae were seen on leaves and feeding. Population declined drastically between 12 to 15 hrs but again noticed at 16.30 hrs. Few grubs were observed on the leaf on cloudy days (17).

Growth and development

This insect can complete its life cycle on *B. campestris* vars. Toria, Dichotoma and Sarson, *B. chinensis, B. pekinsis, B. juncea, B. napus, B. rapa, B. rugosa, B. oleracea* var. Botrytis, *R. sativus and T. majus* but not on *Eruca sativa* (20). Full fed larvae pupate in soil. It prefers sandy soil for pupation having 16-20% soil moisture. Heavy soils are least preferred (24 and 35). Emergence and mating behaviour of this insect have been studied in detail (35).

Eruca sativa, I. amara, C. cheiri and *T. majus* have high degree of natural defense against this insect. Plant juices from fresh leaves act as ovipositional depressants and feeding deterrents (27). Mustard leaves treated with 1% glucosinolates and 0.1% isothiocyanates adversely affect the biology of this insect when offered for feeding. The higher concentrations of 2, 3 and 4% glucosinolate extracts and 0.1 and 1.0 isothiocyanate extract resulted in sharp reduction of larval feeding. This reduction was more in glucosinolate extract from *B. napus, E. sativa and T. majus* and isothiocyanates from T. majus than in extracts from Toria, *B. napus and B. juncea* seeds (1, 2).

Control:

Soil application of Phorate, Carbofuran, Disulfoton and Aldicarb at the rate of @ 1 kg a.i./ha is effective in contolling this insect. Among the various insecticides namely, 10% BHC @ 20 kg/ha, 0.02% Chlorpyriphos, 0.03 Dichlorvos, 0.035% Endosulfan, 0.04% Monocrotophos, 0.05% Phenthoate and 0.025% Quinalphos the use of 10% BHC dust is still effective and economical followed by Dicholorovos and Chlorphyriphos (Table 6).

Table 6. Chemical control of mustard sawfly on rai (1987-88) at Pantnagar

Insecticdes	Yield q/ha	Cost-benefit
BHC @ 20 kg/ha	12.75	1:48.89
Chlorpyriphos @ 0.02	12.75	1:17.50
Dichlorvos @ 0.03	13.00	1:26.74
Endosulfan @ 0.035	12.50	1:17.10
Monocrotophos @ 0.04	12.92	1:11.67
Phenthoate @ 0.05	12.17	1:13.28
Quinalphos @ 0.025	12.33	1:15.18
Control -	9.17	-

Tolerant Germplasm

More than 750 Toria germplams have been screened aginst sawfly and PT-30, PT-33, PT-75, TLC-1, PT 41, PT-48, PT-69 PT-79, PT-80, PT-81, PT-82, PT-83, PT-500, PT-501, PT-5078, RAHT-17, TGC-1, TGC-3, TGC-5, TK, 5503, TK-8202, TKCSP-56, DIDNS-53, PT-12 and PT-303 were found tolerant.

Among rai varieties, PR-15, PR-34, PR-1002, PR 1003, PR-29, RLM-29-25, PR-18, PR-1, PR-6, P-1/26, RL-11/1, 5412, 5501, RH-7-355, Rai 36, Raya-159 and 5503 were found least susceptible to sawfly.

Mustard Aphid

This is one of the most important constraints in rapeseed/mustard reduction in the country. The mean reduction in yield of Toria is 14.9% and sometimes as high as 50% at Pantnagar (20), in sarson and raya 68-96% and 27.66-66.00%, respectively in Punjab (6), 11.6-97% in Delhi (12), 70% in Bihar (9), 55.25% in U.P. (20), 73.3% in Orrisa (15) and 91.3% (8) and 35.4 - 73.3% in Punjab with overall mean damage of 54.20% on country basis (7).

Population dynamics

Winged aphids arrive in the afternoon in numbers and settle on the plant. Yellow colour of the flower is one of the attracting factors for these aphids. In general, on mustard crop aphid appears in the mid of December and its population increases gradually reaching the peak in January/February declining in subsequent months and disappears in March/April, but on longer duration crops such as *B. napus and B. carinata* the highest aphid population is observed druing March/April.

Food preference

Among *B. campestris* var. Toria, sarson and *B. juncea* the last one is less preferred by the aphid. Between Toria and sarson, the former one is more preferred and also completes its growth and development quickly. However, *B. napus* is more suitable for aphid at its flowering and pod formation stages in the absence of *B. campestris and B. juncea.* In addition to these *B. alba, B. carinata, B. nigra, Sinapis alba*, *R. sativus*, Cabbage, cauliflower, knolkhol, *B. rapa* are important hosts of this aphid.

Preference test on different varieties and species indicated that Porbiraya (rai), *S. alba*, PR-18 (rai) and Varuna (rai) are more preferred while all the varieites of *B. carinata*, *B. napus*, *B. alba* and *B. nigra* are least preferred at the inflorescence stage. In general, the exotic material of *B. juncea* are less preferred by aphid as compared to indigenous one (19), Table 7.

Table 7. Number of aphid on inflorescence of Brassica species/varieties

Species/ varieties	Number*	Species/ varieties	Number
Brassica alba	6	*Brassica napus*	3
Brassica carinata		Altex	3
PC 1	3	Olivia	2
PC 2	5	Pant n1	2
Brassica juncea		Pant n2	4
Blaze	11	Tilde	4
Lethbridge	14	Trawse	2
PR-15	9	WW 1313	2
PR-18	19	*Brassica nigra*	5
Porbiraya	23	*Sinapis alba*	22
Stoke	7		
Varuna	18		

* Cumulative, total of six days. Sachan and sharma (1986).

Plant parts preference

Before starting the screening program one has to ascertain the suitability of plant parts as various parts and stages differ in several ways. Based on the preference and growth and developmental studies, the pod of the Toria plant is most suitable followed by stalk and tender leaf. Hard leaves are most unsuitable (32). Similar results were also obtained in mustard (Varuna) where pods and tender leaves were more suitable (23).

Screening of germplasm

To find out the sources of resistance in *B. juncea* large amount of material both of indigenous as well as exotic origin was screened under field as well as laboratory condtions. Under field condtions, aphid damage rating (0-5 scale), percent plant infestation and aphid intensity were considered. Under laboratory condtions, growth and development studies, honey dew excretion techniques, cafeteria test for food preference by apterous and cage technique for a late aphids were followed.

a) Growth and development: Under this study different growth and developmental parameters were considered such as aphid survival, developmental period, fecundity, etc. which depicts the antibiosis of the material (21).

b) Honeydew excretion: Honey dew excreted by aphids is allowed to fall on bromocresol green treated filter paper and blue spots develop where honey dew falls. The area of this spot is related to the amount of honey dew excreted. As more honey dew is excreted more susceptible becomes the host (18) (Table 8).

Table 8. Amount of honey dew (mm^2) excreted by *L. erysimi* on different varieties of mustard (18)

Varaieties*	Plant part		Mean
	Leaf	Inflorescence	
RW 2-2 (R)	23.25	25.25	24.25
RW 15-6 (R)	21.67	23.00	22.33
B 85 (R)	23.25	26.42	24.83
RLM 198 (MR)	26.75	29.50	28.12
RH 7361 (MR)	30.16	31.92	31.00
T 6342 (MR)	28.00	30.08	39.04
Varuna (S)	41.00	45.16	43.08
Porbiraya (S)	38.17	43.25	40.71
S. alba (S)	55.17	64.08	59.62

CD at 5% = 2.00 (Test plant)
= 0.94 (stage)
= 2.84 (Test plant x stage)

*R = Resistant, MR = Moderately resistant,
S = Susceptible

c) Cafeteria test for apterous aphid: Test hosts are kept in the periphery at equi distance and aphids, starvested for 6 hrs, are released in the centre. The number of aphids settling on test hosts after a definite interval is counted (21).

d) Cage technique for alate aphids: Cut ends of inflorescence or leaf is kept in plastic vial containing water or plant nutrient solution. These vials are placed in the circumference at equidistance with a radius of 70 cm. In the centre a twig of *B. campestris* harbouring apterous and winged aphids is placed as a source of alate aphid. The entire setup is caged with an 80 mesh wire cage. Number of alate settled on the test plant is counted after six days (19).

Resistant mustard varieties for aphid

Variteis RW-2-2, RW 15-6, RW 15-29-6, RW-33-2, RH 7846, B 85 (glossy, RLM - 198, T 6342, are tolerant to mustard aphid.

Mechanism of resistance

The flowering inflorescence is the main seat of aphid infestation. The possible cause of more susceptibility of toria and sarson could be their tender, dense, compact and thickly packed buds offering highly suitable space for aphid, whereas in *B. juncea* inflorescence is usually long, slender and hardy and provides comparatively less suitable space for aphid settlement (13).

Brassica napus is susceptible at inflorescence because of its yellow colour and compactness, however, the presence of wax on leaf at early stage of the crop renders it unsuitable for aphid settlement. The twigs of *B. carinata, B. nigra and B. juncea* are stiffer and hence are less preferred. Glossiness of the leaf is also responsible for lower preference in *B. napus and B. carinata* (3).

Experiments were conducted to study the possible mechanism of resistance in *B. juncea* varieties (16). Nine cultivars namely, Varuna, Porbiraya and S. alba, RLM-198, RH 7361 and T 6342 and RW-2-2, RW 15-6 and B-85 (glossy) belonging to susceptible, moderately susceptible and resistant groups, respectively, were selected on the basis of their field performance, population buildup, growth and developmental parameters and preference/non-preference tests.

1. Physical factor, trichome density has no effect as *S. alba* has more hair but more susceptible.
2. Among physiological parameters, moisture and pH of host tissue have no effect on aphid. Chlorophyll content has negative correlation whereas carotenoids have positive relationship with aphid population.
3. Biochemical parameters such as protein, sugar and oil content in seed pod are more in susceptible groups.
4. Phenol content in stalk and seed pod impart resistance to the plant.
5. Among plant nutrients, N, P and Na were higher in the susceptible group. On the other hand, K, Ca, Mg, Zn and S were higher in resistant material.

Chemical control of aphid

i) Efficacy of insecticides: Decamethrin was most toxic followed by Cypermethrin Phosphamidon, Mathyl-o-demeton, Dimethoate, Monocrotophos, Quinalphos, Carbaryl, Endosulfan and Sevisulf (31). In another study, again, Decamethrin was best followed by Cypermethrin, Methyl-o-demeton, Fenvalerate, Permethrin, Dimethoate Phosphamidon & quinalphos(33).

ii) Field test: Out of 10 insecticides tested during 1986-87 and 1987-88, Dichlorvos, Chlorphyriphos and Phosphamidon were better, Table 9.

Among the granular systemic insecticides, phorate 10 G at the rate of @ 0.5 kg a.i./ha is most economical for the control of mustard aphid in rai crop (Table 10).

Table 9. Cost-Benefit ratios of chemical control of mustard aphid

Insecticides	Cost/Benefit 1986-87	Cost/Benefit 1987-88
Chlorpyriphos @ 0.025	1:8.48	-
Dichlorvos @ 0.033	1:6.07	1: 8.71
Dimathoate @ 0.030	1:2.07	-
Endosulfan @ 0.035	1:2.46	1:10.26
Formothion @ 0.025	1:3.73	-
Methyl-o-demeton @ 0.025	1:2.35	1: 3.00
Monocrotophos @ 040	1:5.19	1: 4.52
Phenthoate @ 0.050	-	1: 6.05
Phosphamidon @ 0.033	1:6.64	1: 5.54
Quinalphos @ 0.025	1:3.63	1: 3.96

Table 10. Aphid control by granular systemic insecticides

Insecticide	Dose (kg a.i./ha)	Yield (q/ha)	Cost-Benefit
Carbofuran	0.5	12.92	1:3.76
	1.0	13.00	1:1.05
	1.5	12.66	1:1.09
Phorate	0.5	12.66	1:9.20
	1.0	12.33	1:3.77
	1.5	13.00	1:3.64
Control	-	10.83	-

iii) Compatibility with fungicide: Dithane M-45 has synergistic effect on Phosphamidon and Dimathoate. However, fungicide and Monocrotophos are incompatible. Decamethrin, Cyparmathrin, Methyl-o-demeton and Quinalphos can be mixed with fungicide without appreciable loss in toxicity (30).

iv) **Effect of sublethal doses of insecticides on aphids:** Because of improper selection of insecticide and its use, insecticides can produce resurgence like conditions at very lower doses. Decamethrin, Cypermethrin, Fenvalerate and Phosphamidon at LC 10 and LC 20 levels enhance fecundity and reduce nymphal duration (29).

v) Safety of insecticides to coccinellid: Methyl-o-demeton is most safe followed by dimethoate, decamethrin and cypermethrin. Quinalphos, phosphamidon are not safe (34).

vi) Effect of insecticides on oil content: Various insecticides have been reported to change the nutritive value of the plant. The application of dimethoate increased the oil content by 14.62% and with other insecticides it ranged from 0.07 to 11.76% (5). At LC 50 level of Methyl-o-dematon, Cypermethrin and Decamethrin, this increase is 1.27, 1.07 and 1.07%, in aphid free conditions (29).

vii) Effect of insecticides on protein contnent: Insecticides showed an adverse effect on the protein content which increases with the increase in concentration. Protein content of mustard leaf and inflorescence ranged from 2.7 to 3.51 and 2.82 to 3.44%, respectively in various treatments. This is low as compared to control, 4.12 and 4.02%, respectively (25).

Pollination

Rapeseed-mustard crops are pollinated by *Apis carana indica, A. dorsata, A. florea* and *Melipona* sp. Their peak period of activity is from 11.00 A.M. to 1.00 P.M. on rai and 10.30 A.M. to 2.30 P.M. on Toria during peak flowering period (20).

Granular systemic insecticides, phorat and carbofuran, when used for the control of mustard aphid do not disrupt foraging activity of bees. Similarly phosphamidon, methyl-o-demeton, dimethoate and endosulfan at 0.03 concentration did not deter the bees visiting musterd crop (14).

Future Research Needs

1. Screening of germplasm for insect pest resistance.
2. It has been observed that some varieties show tolerance to aphid at one centre but are susceptible at another. This could be due to their biotype and such studies are needed.
3. Aphid arrival is not regular. In some years it is severe but in others moderate or totally absent. For large screening of germplasm a continuous source of aphid is needed. Hence work on rearing of aphid on artificial diet must be initiated which will also help in understanding the role of various organic and inorganic constituents that are responsible for resistance/ susceptiblility.
4. Evaluation of biocontrol agents and their field application should be explored.
5. Ecological studies of various insect pests are lacking which will help in finding out the weakest link in their life cycle that can be explored for their management.

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ECONOMIC PERFORMANCE, POTENTIAL AND CONSTRAINTS IN TORIA PRODUCTION

L.R. Singh

India produced about 13 million tons of oilseeds on 19 million hectares of land during 1984-85. During the year 1986-87, the average productivity of rapeseed in India remained 694 kg/ha as against 200 kg/ha in Korean Republic, 1677 kg/ha in Japan, 1189 kg/ha in neighbouring China and an overall world average of 1326 kg/ha.

The need for increasing productivity and production of oilseeds in India is widely recognized in view of the increasing gap between the home consumption and the domestic production on the one hand, and the increasing import bill on the other. The country is spending over Rs 10,000 millions on the import of edible oil annually, which is next only to the value of import of mineral oil. Keeping this in view, the Indian Government has accorded high priority to oilseed production.

Uttar Pradesh accounts for nearly 60% of the area and production of rapeseed and mustard. It is grown on an area of 485,000 hectares as pure and 1,775,000 hectares as mixed crop. Estimated production and productivity of rapeseed and mustard during 1985-86 were 2,638,900 tons and 694 kg/ha, respectively.

Planning for increasing the production of oilseeds requires not only a thorough analysis of trends in area, production and productivity, but also the economics of improved package of practices. An attempt has, therefore, been made to focus on the following four points:

1. Growth rate in area, production and productivity of rapeseed and mustard in western plains of U.P.

District-wise compound growth rates of area, production and productivity of rapeseed and mustard were worked out through semi-log function for the period 1974-75 to 1984-85 and presented in Table 1.

Table 1. Compound growth rates for the area, production and production productivity for the different districts of western U.P.

Districts	Growth rate Area	Production	Productivity
Badaun	-0.35	-11.00	-0.76
Bijno e	1.26	-0.47	-0.93
Baneilly	5.07	4.16	-0.76
Moradabad	2.94	1.87	-0.62
Muzaffarnagar	14.54	12.43	1.77
Nainital	-5.01*	-5.09	1.62
Pilibhit	-2.91	3.50	-0.76
Rampur	5.86	5.09	-0.16
Saharanpur	21.46	1.75	1.18
Sahajahanpur	-6.35	-7.23	-0.76
Bulandshahr	161.71*	152.92*	30.25*
Ghaziabad	135.27*	122.67*	30.25*
Meerut	130.87*	117.29*	30.26*

* Significant at 5% level.

Note: For the districts of Bulandshahr, Ghaziabad and Meerut, the growth rates refer to the year 1976-77 to 1984-85.

A perusal of Table 1 indicates that there has been significant and positive growth with respect to area, production and productivity in only three districts, namely, Bulandshahr, Ghaziabad and Meerut. Badaun, Nainital, Pilibhit and Shahjahanpur have registered negative growth rates in area though significant for Nainital only. The performance with respect to growth rates in productivity has not been significant in all the districts except Bulandshahr, Ghaziabad and Meerut. In fact, most of these districts registered negative, though not significant, growth in productivity during the period 1974-75 to 1984-85.

2. Economics of toria (Type -9) production (1987-88)

The following shows the economics of toria (Type-9) production on farmers field in Tarai:

Preparation of land	463.36 Rs/ha
Seed and sowing	84.03 Rs/ha
Fer. application	551.44 Rs/ha
Irrigation	155.58 Rs/ha
Harvesting	243.35 Rs/ha
Threshing & winnowing	93.49 Rs/ha
Transportation	15.57 Rs/ha
Interest on working capital	48.33 Rs/ha
Total cost of prod.	1659.41 Rs/ha
Total cost of prod. (including rental value of land)	3221.912Rs/ha
Yield (Q)	8.87 q/ha
Selling price	430.00 Rs/q
Gross income	3815.76 Rs/ha
Net income (excluding rental value of land)	2156.35 Rs/ha
Net income (including rental value of land)	593.85 Rs/ha
Cost of prod. of the main product (excluding rental value of land)	180.85 Rs/q
Cost of prod. of the main product (including rental value of land)	364.45 Rs/q

The estimates of the cost of production are based on the data procured from 76 farmers. The cost of production was worked out to be Rs 180.85/quintal when rental value of land was excluded from cost of production. However, when rental value of land was included in cost of production, it increased to Rs 364.45/q. The net return comes out to be Rs 593/ha over the cost of production including rental value. However, the profit margin increased to Rs 2156/ha when rental value is not included in the cost of production.

3. Economics of irrigation, fertilizer use and production potential

Economics of irrigation and fertilizer application was worked out through response analysis*. Table 2 gives estimates of benefit-cost ratio at different levels of nitrogen-irrigation combinations and different prices of input and output. In addition, the optimum level of fertilizer application under different input and output prices is also given. It can be observed that, with the given price of toria as Rs 430/q, the price of one irrigation as Rs 150, and the price of nitrogen as Rs 5.43/kg, the optimum dose of nitrogen becomes 114.18 kg/ha. The benefit-cost ratio of one irrigation in the same set becomes 3.44. The benefit-cost ratio of nitrogen becomes 5.43. But, when the effect of nitrogen and irrigation is taken together, the benefit-cost ratio becomes 5.04. With the increase of nitrogen price from Rs 5.43 to Rs 5.97/kg (i.e. 10%), the benefit-cost ratio of nitrogen use comes down to 4.98 and that of nitrogen-irrigation together decreases to 4.70. It can be concluded that it is quite remunerative to use optimum level of nitrogen upto 110 kg/ha in association with one irrigation. Also, even with one irrigation coupled with optimum level of nitrogen, the production potential is as high as 17 q/ha.

4. Constraints in lahi (toria) production

For the study of constraints, 30 farmers, from each of small, medium and large size groups were interviewed and thier responses were recorded. The nature of constraints as stated by farmers of the area is shown in Table 3. The brief discussion regarding constraints may be put as follows:

Table 2 Economics of irrigation and fertilizer use and production potential

Toria price (Rs/q)	One irrigation price (Rs.)	N price (Rs.)	No of irrig.	Optimum level of N (kg/ha)	Yield from irrig. (q/ha)	Benefit cost ratio to irrig.	Yield from N (q/ha)	Benefit cost ratio to N	Total yield (q/ha)	Yield from both (q/ha)	Benefit cost ratio to both
430	150	5.43	1	114.18	1.20	3.44	7.83	5.43	17.40	9.03	5.04
430	150	5.97	1	112.87	1.20	3.44	7.81	4.98	17.38	9.01	4.70
430	150	5.43	2	114.18	1.62	2.32	7.83	5.43	17.82	9.45	4.47
430	150	5.97	2	112.87	1.62	2.32	7.81	4.98	17.80	9.43	4.16
500	150	5.43	1	115.96	1.20	4.00	7.85	6.23	17.42	9.05	5.80
500	150	5.97	1	114.85	1.20	4.00	7.84	5.72	17.41	9.04	5.41
500	150	5.43	2	115.96	1.62	2.70	7.85	6.2	17.84	9.47	5.09
500	150	5.97	2	114.85	1.62	2.70	7.84	5.72	17.83	9.46	4.80
600	150	5.43	1	117.80	1.20	4.80	7.87	7.38	17.44	9.07	6.89
600	150	5.97	1	116.00	1.20	4.80	7.86	6.76	17.43	9.06	6.41
600	150	5.43	2	117.80	1.62	3.24	7.87	7.38	17.86	9.62	6.06
600	150	5.97	2	116.88	1.62	3.24	7.86	6.76	17.86	9.48	5.70

Table 3. Constraints in adoption of toria as stated by 30 farmers each from different size groups of farms

Constraints	Percentage of farmers in size groups Small	Medium	Large
Susceptibility of the crop to insects, pests and diseases	80	70	63
Excessive rainfall, causing delay in sowing of toria	93	80	60
Inclusion of toria delays the cultivation of succeeding crop	77	37	17
Lack of suitable HYV seeds of early paddy, toria and late wheat	77	27	7

a) Susceptibility of crops to insects, pests and diseases: Alternaria blight disease; aphid and sawfly pest, and frost cause severe damage to toria crop. This problem was felt by 80% of small farmers, 70% of medium farmers and 66.33% of large farmers.

b) Excessive rainfall causing delay in sowing of toria: Excessive rainfall caused a delay in growing of toria, which in turn not only reduced yield but also made the crop more prone to diseases, pests and frost. This problem was felt by 93% of small farmers, 80% of medium farmers and 60% of large farmers of the area.

c) Inclusion of toria delays the cultivation of succeeding crop: About 77% of small, 37% of medium and 17% of large farmers confirmed that inclusion of toria crop causes a delay in the cultivation of succeeding wheat crop.

d) Lack of suitable HYV seeds of early rice, toria and late wheat: Quite a large number of farmers, particularly small farmers, felt that there is a lack of suitable and high yielding variety of short duration paddy to facilitate the cultivation of toria on optimum time. They also felt the need for suitable late variety of wheat.

General Observations and Conclusions

While in the past, the changes in the production of oilseeds have been largely due to area effect, it was observed that the future changes in production will have to be brought through yield effect. In this context it has been observed, through some sporadic studies, that even the available technology is not being fully exploited by the majority of the farmers and sizable yield gaps exist between the potential yield already attained by some progressive farmers and the average local yields within the similar agro-climatic and resource endowment situation under both irrigated and unirrigated conditions. This calls for yield gap studies, identification of the factors affecting yield in different agro-climatic regions and the diagnosis of the monetary as well as non-monetary aspects of the available technology responsible for such yield gaps so that farmers become educated through proper extension input. It has also been observed that the farmers are hesitant in making capital investment particularly in oilseeds production. This was largely due to yield instability and price risk. Despite the announcement of minimum support prices in oilseeds, the procurement system is reported not to be functioning effectively in these crops. Being grown largely on marginal and sub-marginal lands and under unirrigated conditions, the yield risk is very high due to prevailing moisture conditions, diseases and pest attack and inadequate use of capital inputs. It is, therefore, necessary that studies be conducted to demonstrate the returns of investing in disease and pest control and the use of capital inputs like fertilizer under dry land conditions in this crop.

RAPESEED IN EGYPT

Badr A. El-ahmar

Oil crops occupy about 230,000 faddans (1faddan = 4200m^2) out of which 127,000 faddans are for soybean, 35,000 faddans for sunflower (both confectionery and oil types), 40,000 faddans for peanut and 25,000 faddans for sesame. There was no acreage for rapeseed on farmers' fields before 1988. Cotton seed is the main source of edible oil followed by soybean, The local production from this commodity is still far below the actual annual needs since it covers about 20% of the actual consumption which amounted to 600,000 Mt in 1987. The per capita consumption is about 12kg/year, which is much below the consumption level in developed countries. The estimated consumption in the year 2000 will exceed one million Mt.

If the national production will not increase over 120,000 Mt., the gap will be very wide, and the government will have to import annually 950,000 Mt of edible oil from international market, if available. To avoid this serious situation, we must have other edible oil sources. Rapeseed and sunflower as winter crops (upper Egypt) and as summer crops (all over the country) can play an important role to partially cover this gap.

Rapeseed (*B. napus*) performed good in the northern part of the country in both low fertile soil in the valley and the newly reclaimed land in the west and east of the Nile Delta.

Before 1988, it was not allowed to cultivate rapeseed in farmers' fields because rapeseed oil was not included as edible oil in the Egyptian Code. In 1988, rapeseed oil was legally added as an edible oil in Egypt if the erucic acid is lower than 2%. For the first time, rapeseed was sown in 1000 faddans in farmers' field on contract with Oilcrops High Council to be more satisfied concerning the marketing.

Objectives of the Breeding Program

The rapeseed breeding program is just started in Egypt. The following are the objectives of our present and future work.

1. Oil Quality

- High quality varieties i.e., the released varieties must have low erucic acid (not more than 2% of the total fatty acids in the oil). The erucic acid in promising varieties is far below that. The glucocinolate percent in the meal is around 100 umoles. So, in order to improve, oil and meal qualities, a crossing program was conducted.

In 1987/88, more than 40 crosses were made and the hybrid seeds, weresown in 1988/89 season as F_1 along with 20 other crosses in F_2 and F_3 generations. This will offer a wide genetic variability for selection.

2. Early maturing varieties

Earliness is an important factor of the rapeseed breeding program. Due to the limited land resource, intensive cultivation will help the farmer to plant more than two crops a year.

To achieve this goal, a crossing program was suggested (inter-and/or intra-specific). For example, *Brassica kaber* under Egyptian conditions during winter, starts its flowering at the end of December. Following different techniques, crossing between *B.*

kaber B. napus, B. campestris, B. juncea and *B. carinata* will be made in cooperation with the cytological laboratory.

The future expansion of rapeseed cultivation will be in the new land, which is either calcarious or clay soil; both suffering from high salinity. As a result, it is important to have in the germplasm collection a source for salinity resistance. Thus, a cooperated effort with the Physiology Department and Soil Water Institute for screening the available germplasm collection and the segregating generations was started.

3. Drought resistance

Due to the intensive cultivation in the valley and water source limitations in the new land. genotypes resistant to drought reasonable yield are essential. To find such genotypes, all the rapeseed collections and segregating generations were sown under rain fed conditions in the north coast, the annual precipitation of which is very low (100-200 mm).

The screening of these materials will be carried out in the laboratory using different doses of salty water for irrigation. The obtained result will be used as an indicator for salinity tolerance or resistance as well as for drought tolerance or resistance.

4. Shattering resistance

The majority of germplasm available at hand (200 lines) shatters at harvest time, especially in late harvesting (June) due to the high temperature prevailing during this period, and large quantity of seeds was lost, affecting negatively the actual seed yield. So, semi- or non-shattering varieties are needed.

A program for selecting a semi- or non-shattering genotype was conducted; the applied technique of which is very simple. The generations advanced from F_2 up to F_4 were kept in the field without being harvested for more than 20 days after full plant drying. The harvest was done manually by shaking. All the plants which appeared tolerant or resistant to shattering were selected and sown in 1988/89 separately.

5. Diseases and broomrape

Rapeseed plants in Egypt faced a serious disease problem which affected severely the seed production. The most dangerous pathogen is *Selerotinia* which attacks the roots and crown making the plant wilted and dried.

The other serious disease is white rust, which appeared for the first time last season in the three breeding nurseries causing a great damage to the plants.

For *Sclerotinia*, a nursery was established at Giza Research Station. The promising lines and segregating generations were sown in soils infested with the pathogen and broomrape (*Orobanch ramosa*) in 1987/88. The selected plants have been sown in the same nursery this season. Intensive selection will take place.

THE ROLE OF HIGH-YIELDING VARIETIES AND PRODUCTION TECHNIQUES ON OILSEED BRASSICA PERFORMANCE IN THE CENTRAL, SOUTH-EASTERN AND NORTH-WESTERN ZONES OF ETHIOPIA

Hiruy Belayneh, Getinet Alemaw and Nigussie Alemayehu

Abstract

Ethiopia has a long history of growing Ethiopian mustard (*Brassica carinata* A.Br.) while the Argentine rapeseed (*B. napus*) was introduced into the country about 16 years ago. A collaborative research with national institutions has led to the release of six Ethiopian mustard (S-67, S-71, S-115, Awassa population, Dodolla-1 and yellow Dodolla) and four Argentine rapeseed (Target, Tower, Pura, Tower sel 3) varieties. The production techniques for the two oilseed *Brassica* species has been perfected. On the basis of these findings, on-farm trials and demonstration plots were laid out in progressive farmers' fields in different mustard growing localities of the country. The results revealed that there is a possibility of achieving 2-3 fold increase in the yield of Ethiopian mustard by proper utilization of the available production technology. There was also an upward trend in both production per unit area and acreage of rapeseed under state farm conditions. Factors such as improved variety, proper seed bed preparation, sowing at optimum time, fertilizer application based on soil analysis, correct weed control and right stage of harvest are now recognized as being critical in improving oilseed *Brassica* production in the highlands of Ethiopia. Cost/benefit analysis was exercised in assessing the real value of the new technology. There is a great scope for further increase in oilseed *Brassica* acreage.

Ethiopian mustard (*Brassica carinata* A. Br.) is an important oil crop of Ethiopian origin (5). It is grown by subsistence farmers under rainfed condition using traditional methods. On the other hand, a sizable area of Argentine rapeseed (*B. napus*) variety is cultivated on state farms (4). The *B.napus* was introduced in the country about 16 years ago. Ethiopian mustard occupies 53,000 hectares of land and accounts for an annual production of 24,900 Mt in the country (3). The present low national average yield of the crop is due to low yielding ability of the traditional varieties and poor management.

During the past decade, the Highland Oil Crops Team consisting of breeders, agronomists, soil scientists, and plant protection specialists, handled several production problems of oilseed *Brassica* inorder to develop the appropriate technology for improving yield per unit area. As a result, the oilseed scientists generated the optimum combination of management practices. However, in spite of the availability of high productive mustard and rapeseed production technology, a wide gap still exists between the experimental yields and the average yield obtained from farmers' fields. Consequently, more emphasis was placed on extending improved crop production technology to farmers. It is the purpose of this paper to examine the experimental and large-scale yield potential of the new technology.

Materials and Methods

The oil crops program has adopted a three-phase approach in formulating and verifying the technology package suitable to the area served. The first phase, focused on the development of appropriate technology which was carried out by the research scientists within the premises of research centers, associated sub-centers, and trial sites. In the second phase, the on-station verification trials were carried out "in fences" at research centers while the on-farm research activities were undertaken "outside fences" on representative farmers' fields under farmers' conditions inorder to assess the effectiveness and appropriacy of the package before it is recommended. The emphasis in the final stage was on popularization so as to enhance accelerated diffusion of the validated technologies.

In the on-farm activities, two *B.carinata* (S-67 and local check) and one *B.napus* (Pura) were tested under both improved and farmers' methods. The surveys in the target areas provided information that the majority of the farmers are small holders and practice intensive cultivation using family labour and low level of inputs. Hence, the farmers' method includeds the normal traditional method of mustard production which include a combination of one mid-season hand weeding, a seed rate range of 8-10 kg/ha, and zero or 23/35 kg/ha of N/P_2O_5 fertilizer. The improved package included the recommended fertilizer rate of 46/69 kg/ha of N/P_2O_5 two hand weeding at 25-30 and 50-60 days after sowing and seed rate of 12 kg/ha. In both methods, the local plough was used for land preparation and the seed was broadcasted. Sowing date of each variety at each site was done according to local farmers' practices which was similar to the researchers' recommendation. The trial was replicated at least three times at each location. The plot size for each treatment was 200 m^2. The researchers and extensionists were involved in site selection, plot layout preparation and data collection, while the packages were administered by the farmers under supervision. In the production demonstrations, the best treatment combinations were chosen and compared with common practice on quarter hectare of land at a number of farmers' fields. One improved variety, S-67 with its package, was tested against a local variety with its traditional practices. Data on the cost-benefit ratio was recorded in order to find out the real value of the new technology in farmers' fields. Both the Agricultural Marketing Corporation (AMC) and local market (LM) prices were used to calculate the value of the produce. The cost of labour for weeding was taken at 2 birr (1 Birr=.49 US$) per 7 hrs. The primary management responsibility of the plots rested on the farmers.

Results and Discussion

Over the years, the oilseed Brassica breeding program has made a substantial effort in the identification and release of improved mustard and rapeseed varieties. To date, six Ethiopian mustard (S-67, S-71, S-115, Awassa population, Dodolla-1 and Yellow Dodolla) and four Argentine rapeseed (Target, Tower, Pura and Tower Sel. 3) varieties have been released. These improved varieties came out of simple selection from local and exotic material. Results of the multi-location trials showed that the late maturing Ethiopian mustards (*B.carinata*) outyielded rapeseed (*B.napus*) under long growing season conditions of the Ethiopian highlands, Tables 1 and 2. On the other hand, the mean oil content of rapeseed was greater and the plants, shorter than the Ethiopian mustard, Tables 3 and 4.

Several cultural practice trials with *B.carinata* and *B.napus* in Ethiopia showed that seed yields were more influenced by fertilizer, weeding and sowing date than by differences in plant population, Table 5.

Table 1. Summary of seed yields (kg/ha) of the released and local varieties in the rapeseed and mustard national and extension variety trials grown at 10 sites in four agricultural development zones (ADZ) with 46/69 kg/ha of N and P_2O_5 fertilizer (F_1) or without (F_0), 1984-1986 (Number of locations in parenthesis) (2,7,8).

		ZONE									
		Central (2)		South-eastern (3)		North-western (4)		Western (1)		Mean (10)	
Species	Variety	F_1	F_0	F_1	F_0	F_1	F_0	F_1	F_0	F_1	F_0
B.napus	improved	1867	1282	1636	683	1630	561	1353	129	1621	664
B.carinata	improved	2992	2323	2605	1320	2034	1069	2899	291	2632	1251
B.carinata	local	2724	2144	1897	1132	1699	718	2018	183	2085	1044
	Mean	2528	1916	2046	1045	1788	783	2090	201	2113	986

Table 2. Number of days to maturity of the released and local varieties in the rapeseed and mustard national and extension variety trials grown at 10 sites in four ADZ with 46/69 kg/ha of N and P_2O_5 fertilizer (F_1) or without (F_0), 1984-1986 (Number of locations in parenthesis) (2,7,8).

		ZONE									
		Central (2)		South-eastern (3)		North-western (4)		Western (1)		Mean (10)	
Species	Variety	F_1	F_0	F_1	F_0	F_1	F_0	F_1	F_0	F_1	F_0
B.napus	improved	131	136	153	161	148	149	137	158	142	151
B.carinata	improved	152	154	164	175	155	159	157	168	157	163
B.carinata	local	151	153	168	175	167	170	174	179	165	169
	Mean	145	148	162	170	157	159	156	167	155	161

Table 3. Seed oil content (%) of the released and local varieties in the rapeseed and mustard national variety trials grown at four sites in two ADZ with 46/69 kg/ha of N and P_2O_5 fertilizer (F_1) or without (F_0), 1984-1986. (Number of locations in parenthesis) (2,7,8)

		ZONE					
		Central (2)		South-eastern (2)		Mean (4)	
Species	Variety	F_1	F_0	F_1	F_0	F_1	F_0
B.napus	improved	45.9	45.2	45.9	46.0	45.9	45.6
B.carinata	improved	42.4	42.3	43.2	41.9	42.8	42.1
B.carinata	local	42.2	41.2	43.0	42.2	42.6	41.7
	Mean	43.5	42.9	44.0	43.4	43.8	43.1

Table 4. Plant height (cm) of the released and local varieties in the rapeseed and mustard national and extension variety trials grown at 10 sites in four ADZ with 46/69 kg/ha of N and P_2O_5 fertilizer (F_1) or without (F_0), 1984-1986 (Number of locations in parenthesis) (2,7,8).

		ZONE AND NO. SITES									
		Central (2)		South-eastern (3)		North-western (4)		Western (1)		Mean (10)	
Species	Variety	F_1	F_0	F_1	F_0	F_1	F_0	F_1	F_0	F_1	F_0
B.napus	improved	145	132	142	110	122	103	131	83	135	170
B.carinata	improved	175	163	170	124	150	127	179	103	169	129
B.carinata	local	182	164	176	130	153	127	177	120	172	135
	Mean	167	153	163	121	142	119	162	102	159	124

The results from researchers' managed on-station verification trials indicated that, mean seed yields ranged from 2006 - 2567 kg/ha for Ethiopian mustard and from 1256 - 1500 for rapeseed, Table 6.

Table 5. Seed yield increase due to optimum cultural practices as compared to the checks (farmers' methods) (6)

Species	PERCENT INCREASE DUE TO				
	Fertilizer (Recom.-Nil)	Weeding		Sowing date	Seed rate
		Once	Twice	(15 June - 15 July)	6-12 kg/ha
B. carinata	93.5	-	-	20.5	5.6
B. napus	147.4	79.1	83.7	26.0	8.6

Table 6. Summary of seed yields (kg/ha) of the released varieties in the rapeseed and mustard station verification trials grown at three research centers in three ADZ 1986 and 1987 (unpublished).

Species	Variety	Holetta (Central)	Kulumsa (South-eastern)	Adet (North-western)	Mean
B. napus	improved	1463	1500	1256	1406
B. carinata	improved	2627	2567	2006	2400
	Mean	2045	2034	1631	1903

The on-farm trials revealed that the average seed yields of rapeseed were only 58.2% of the Ethiopian mustard yield. Both species responded very well to the optimum management conditions and rapeseed was more responsive to management. About 119% of the increase in mustard mean seed yield can be attributed to improved cultural practices and only 32.2% was due to variety. The traditional mustard varieties presently grown by the farmers can be made to produce acceptable yields by improving the conditions under which they are grown, Table 7. Under the farmers' conditions, the released mustard variety, S-67, yielded about 22% more than the local cultivars grown in the area, although over 180% yield increment has been possible with the optimum management.

Table 7. Mean seed yield (kg/ha) of two released and one local varieties in the rapeseed/mustard on-farm trials grown at three ADZ using farmers' methods and researchers' packages, 1985-1986 (1,6).

Agricultural Development Zone	Number of sites	FARMERS' METHOD			RESEARCHERS PACKAGES		
		B.napus (Pura)	*B.carinata* (S-67)	*B.carinata* (local)	*B.napus* (Pura)	*B.carinata* (S-67)	*B.carinata* (local)
Central	8	260	1100	940	770	1880	1530
South-eastern	6	160	260	170	520	840	390
North-western	18	223	373	310	1000	1283	997
	Mean	214	578	473	763	1334	972

The data in Table 8 indicate that the performance of the recommended variety, S-67 planted in relatively large plots under improved management condition, was better than the local varieties grown in the areas under traditional practices. Seed yield varied from 1300 - 1800 kg/ha for improved practices and from 800 - 1080 kg/ha for farmers' practices. Thus, there is a possibility of achieving a substantial increase in mustard seed yield by using improved varieties along with the recommended package of cultural practices.

Table 8. Seed yield (kg/ha) of mustard varieties grown in production demonstrations at five locations in Menagesha Awraja (Central zone), 1987 (1).

Demonstration site	Altitude (m)	Soil type	Varieties Local	Varieties S-67	Increase (%)
Wolmera Goro	2400	Nitosol	940	1800	91.5
Wolmera Chocke	2400	"	1080	1360	25.9
Sademo	2400	"	1040	1600	53.8
Chiri	2400	"	890	1800	102.2
Ada Berga	2600	"	800	1300	62.5
Mean			950	1570	65.2

During the period from 1982 to 1988, there was an upward trend in both production and acreage of rapeseed under state farm conditions Table 9. In 1982, the state farms in south-eastern zone had 207 ha under rapeseed and increased to 7299 ha in 1988 due to the adoption of new improved varieties and extended use of improved cultural practices such as proper seedbed preparation, drilling at optimum time, fertilizer application, correct weed control (use of herbicide such as Fluaziofop-butyl, Haloxyfop, Metolachlor and Alachlor) and right stage of harvest. Rapeseed yield at Lolle was outstanding: 2090 kg/ha over 218 ha in 1986 was a remarkable figure, Table 9. In general, it has been clearly shown that by adopting good husbandry practices, oilseed *Brassica* seed yields per unit area can be doubled. The areas under rapeseed production are expected to increase progressively every year. It has been estimated that during the 1989 crop season, about 10,200 ha will be sown under Tower Sel$_3$ in the south-eastern region.

Table 9. Area (ha) and average seed yield (kg/ha) of rapeseed in selected state farms (south-eastern zone), 1982-1988 (9).

State farm	1982 Area	1982 Yield	1983 Area	1983 Yield	1984 Area	1984 Yield	1985 Area	1985 Yield	1986 Area	1986 Yield	1987 Area	1987 Yield	1988* Area	1988* Yield
Lolle	207	590	123	1040	Insect	Pest	154	1390	218	2090	305	1810	420	2100
Diksis	-	-	-	-	-	-	77	680	159	680	235	1290	985	1200
Goffer	-	-	-	-	169	780	150	1070	338	790	365	1340	691	1200
Herero	-	-	-	-	176	620	322	790	406	1120	519	720	523	1200
Surufta	-	-	-	-	82	480	223	1110	321	1240	478	1250	1003	1300
Sinana	-	-	-	-	-	-	163	1100	245	1180	-	-	497	1300
Mean	207	590	123	1040	142	627	182	1023	281	1183	380	1282	687	1383
Total Area (all state farms)							1089		2381		2988		7299	

*yield (kg/ha) is an estimate.

Economic analysis of costs and returns for the new technology was carried out under farmers' conditions. Factors such as time of sowing and number of ploughing were the same for both improved and traditional practices. Thus, while testing the recommended package, the emphasis was on the cash inputs such as fertilizer, seed and labour for weeding. The Marginal Rate of Return (MRR) for Agricultural Marketing Corporation and Local Market prices were bin 29.4 and 139.1 (1 bin = 49 US$) Table 10.

Summary and Recommendation

As a result of a well organized research activities, the oilseed *Brassica* improvement program has made great strides with the development of ten high yielding and disease resistant varieties of

Table 10. Partial budget analysis of the effect of the recommended packages of mustard (S-67) in Menagesha Awraja (Central zone), 1987 (1).

Factor	Farmers' method	Improved method
Variable cost	Local	S-67
Cost of seed (birr/ha)	85.0	88.9
Cost of fertilizer (birr/ha)	85.6	171.1
Cost of weedinf (birr/ha)	0	131.0
Total	170.6	391.0
Benefit		
Yield q/ha	9.5	15.7
Gross benefit AMC* (46 birr/q)	437.0	722.2
" " LM** 85 "	807.5	1334.5
Net benefit AMC	342.9	409.4
LM	713.4	1027.7
Marginal Rate of Return (MRR)		
AMC	-	30.4
LM	-	140.5

* AMC = Agricultural Marketing Corporation price.
** LM = Local Market price.wide adaptability.

Information on agronomic practices was also made available at the time the new varieties were released. Under better draining soils, improved varieties and fertilizer can be productive, provided that other cultural practices such as early sowing and early weeding are applied.

The results from on-farm trials revealed that the rapeseed average yields were only 58.2% of the Ethiopian mustard under farmers' conditions. The optimum management increased the seed yield of Ethiopian mustard by 180% on farmers' field when compared with the traditional practice.

There was an upward trend in both production per unit area and acreage of rapeseed under state farm conditions. This increase in seed yield and acreage is attributed to both improved varieties and suitable production techniques.

Fertilizer is very vital for increasing seed yields. However, its use should be based on soil analysis. The use of improved seed and fertilizer do not pay in the absence of good husbandry practices such as proper seedbed preparation and weeding.

These findings have no value unless they are used by the farming community. Consequently, more emphasis need to be placed on popularizing the improved production technology to farmers through a large number of pilot-production-cum-demonstrations and training programs. It should not be forgotten that the availability of input and strong price incentives accelerate the production and productivity of oilseed *Brassica*.

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THE ACHIEVEMENTS AND FUTURE OF BRASSICA IN KENYA

M.J.Mahasi

Abstract

Due to their wide adaptability, many Brassica species can be grown in Kenya. These plants are grown for their different edible parts. From the point of edible vegetable oil, B. napus, B. *campestris* and B. *juncea* have been experimented on and found to do well in this country. The demand for vegetable oils and fats has been increasing with the increase in population and since the country produces only 1/3 of her total annual requirements, this calls for importation. Government policy aims at self-sufficiency and import substitution through increased productivity.

The major achievements in the oil seed Brassicas have been: Development of high yielding varieties and their release, high oil and protein content, improvement in the quality of the oil and meal, screening for disease and pest resistance, modification of plant stature (semi-dwarf/bunchy types), increased number of introductions from diverse origins, identification of new sites, interspecies crosses to increase genetic diversity, economics of production based on on-farm trials, research interlinkages, non-shattering, yellow seeded types and acid tolerance.

The future of oilseed Brassica in Kenya is outlined.

Many Brassica species have been cultivated since pre-historic times for their edible roots, stems, leaves, buds, flowers and seeds. Within a species, crops have been developed for different purposes. From the edible oil point of view, three species have been experimented on and found to do well in Kenya. These are *B. napus*, *B. campestris* and *B. juncea*. The first two are referred to as oilseed rape or rapeseed and the last comprises the mustards. Only the spring type rapeseed can do well under our environment.

The demand for vegetable oils and fats has been increasing with the increase in population but the country produces only about 20-30% of her total needs. Sunflower and simsim are the two important oil crops currently grown for vegetable oil extraction. There is an urgent need to bridge the gap between local production and the export market by exploring other oil crops that can grow under Kenyan conditions. Rapeseed is one such a crop adapted to the higher potential wheat/barley growing areas. The Brassica species have wide adaptability and perform well under a wide range of climates. The acreage under rapeseed has declined drastically since 1982 due to factors like lack of finance, competition from high valued cereals, land subdivision etc.

The country aims at self-sufficiency and import substitution through increased productivity. Presently, vegetable oils and fats are some of the largest imports of agricultural products in Kenya. The residue meal after oil extraction is valued in the animal feed industry as a protein supplement.

Major Achievements

Seed Yields

Introductions, after screening, have been tested at various sites where the Brassicas are known to grow and high yielding cultivars identified as shown in Table 1.

Table 1. Mean seed yields across four locations in kg/ha

	Location				Mean
Genotype	Njoro	Mau-narok	Timau	Eldoret	Across location
Cressor	1075	1893	2170	1121	1322
Altex	880	1379	1577	-	1066
Westar	1079	1073	2127	1095	1152
Mary	1003	1933	1444	1707	1290
Niklas	1292	2155	2086	1265	1447
Tower	1225	2254	2986	1244	1649
Willi	318	3591	2150	-	1631
Regent	1177	1940	1412	646	1100
Topaz	951	2899	1999	1946	1670
Christa	364	3190	1417	-	1344
Oro	877	2255	2789	1320	1540
Line	930	1939	2361	729	1315
Gulliver	1207	2512	2425	1486	1659

Due to their excellent yields and disease resistance, Topaz, Gulliver and Niklas have been released for commercial production. The Canadian varieties Altex, Wester, Tower, Regent and Oro have also been recommended for release. Their potential yields increase when conditions are ideal.

Oil and Protein Quality

Up to 1982, the varieties introduced were found to be very high in erucic acid content and everything possible had to be done to eliminate them from circulation. At the same time (low erucic acid and low glucosinolate) types were introduced into the country. Those under test have an average oil content of 44-48%. The low erucic rapeseed varieties are determined by the level of fatty acids. A maximum amount of 5% erucic acid is considered safe in edible oil products.

Disease and Insect Pests

This is a major problem in productivity of rapeseed in Kenya. Blackleg (*Phoma lingam*) is a serious disease of rape and can result in total crop failure. The disease may be carried on weeds of the Brassica family. So far, three lines from Australia, known to carry resistance have been screened for 2 years and are going to be utilized in backcrosses to introduce the resistance into our commercial varieties. At the moment, farmers are advised to reduce the frequency of rapeseed to once in 4 or 5 years and burn crop residues. Chemicals for seed-dressing tend to be expensive and uneconomical.

The other diseases that can cause considerable damage are white leaf spots and sclerotinia stem rot. Resistant cultivars are not available and so cultural control is recommended. As for insect pests, the following have been noted: cutworms, flea beetles, sawflies, diamond back moths, American boll-worms, semi-loopers, aphids, and birds.

Apart from birds that need bird scaring devices, chemicals are available to control the others. This has to be done at economic levels. Aphid resistant cultivars are sought.

Introductions

A lot of rapeseed and mustards from diverse origins have been brought in during the last six years. These have been screened and some entered into the performance trials. Characters like plant height are to be improved using the semi-dwarf introductions. Yellow-seeded types (low in fibre) and non-shattering cultivars are also selected.

New Sites

Rapeseed grows between 1820-2800m a.s.l. Its expansion has been reduced by the relative price of wheat and barley which are also grown here. Observation plots have been conducted in the marginal/lower zones in the last two years and it has been noted that *B. campestris* and the mustards tend to perform well. Early maturing types have been identified for the drier zones.

Crosses

An interspecies crossing program has been initiated to increase genetic variability. Four genotypes of each of the species i.e., *B. napus*. *B. campestris* and *B. juncea* are being utilized. The characters that are to be incorporated in the F1 are: earliness, disease resistance, high seed yields, shattering resistance and oil and protein quality. Seed setting has been found to be higher within species, than between species.

Cost Reductions

A proper seedbed is critical in determining the ultimate plant population. Seed wastage is also minimized when one starts off with a clean, fine and firm seedbed. Farmers have reported that fertilizer costs are reduced by using TSP at 50-100 kg/ha than DAP at 150 kg/ha. On-farm trials have been conducted to establish the economics of production.

Research Interlinkages

Of late, this has improved a great deal. We now collaborate with private institutions, Kenya Seed Company, Oil Crop Development, the industries, Oil Crops Network e.t.c. With about 14 crushing plants in the country, the market is guaranteed.

Acid Tolerance

Westar has been identified as acid tolerant and thus can be grown in acid problem areas.

The Future of Oil Brassicas in Kenya

1. Either prices should be increased to match those of the high value cereals like wheat and barley or seed yields should be increased. The latter is possible through development of high yielding varieties and good crop management.
2. Other oil yielding Brassicas should be encouraged at the lower zones (*B. campestris* and *B. juncea*).
3. The future is a bit dim for the large-scale farmer because financing bodies are not available hence, stands high risks in production.
4. Concentration should be on small-scale and non-shattering types grown e.g. mustards and Ethiopian types, marginal production should be promoted since *B. campestris* and the mustards are early maturing.
5. Technology suitable for the small-scale farmer must be developed to minimize pre and post-harvest losses.
6. Plans are underway to try and encourage village-level oil extraction and the appropriate technology required for this.
7. In future, the crop should

be swathed at 30-35% moisture to minimize yield losses.

8. The use of crop desiccants for hastening maturity and speeding up the drying of the late pods should be tried and the economics of their use assessed.

9. Sickles for small-scale farmers are highly recommended.

Finally, oilseed Brassicas have a bright future in this country due to their wide adaptability, high oil yield per unit area and high protein in the meal. Therefore, ways and means have to be sought so as to encourage greater production.

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RAPESEED ADAPTATION TRIALS IN CYPRUS[1]

A. Hadjichristodoulou

Abstract

Variety and spacing trials, and observations on sowing date of rapeseed were conducted during the period 1984-88 under rainfed conditions or with supplementary irrigation. Average grain yields of *Brassica napus* varieties were as high as 3.4 t/ha and in some favourable environments were even higher (5.9 t/ha). All varieties flowered in March and matured by late May. They were tall (150 cm) and produced small grains (2-3 mg), of 67-79 kg/hl volume weight, 36-40% oil content and 24-25% crude protein content. It is expected that rapeseed will produce 1.3 t/ha of seed oil, and 2.2 t/ha of meal as a by-product, which is a high protein (40%) livestock feed. *Brassica campestris* varieties were earlier but gave lower yields than *B. napus* varieties. Populations of 38-130 plants per m^2 gave similar yields. Irrigation increased yields. It is concluded that rapeseed can be successfully grown in Cyprus because it matures before the onset of drought in late spring-early summer. Sowing must be done in November. Late and tall varieties producing large grains and the highest yields. Breeding must aim to produce varieties with a short period at the rosette stage, in order to reduce competition by weeds.

The Agricultural Research Institute initiated, in 1980, a program aimed at examining the possibility or growing oilseed crops in Cyprus. The first crops studied were safflower, soybeans and sunflower 6, 7, 8). Rapeseed was then introduced and tested under both rainfed and irrigated conditions. Cyprus imports all the seed oils and feed meals it needs. An oil-refining factory is in operation, and there is also a factory (at Paphos) which can extract oil from seeds, but it is not yet in operation.

Brassica oilseed varieties are grown widely in India, China, Pakistan, Europe, Canada and Australia, but not in the Middle East, North Africa and the Mediterranean area (11). Recently developed varieties of rapeseed produce good quality oil and meal (low in alkaloids). These varieties are known in Canada as Canola (1).

Rapeseed oil was used centuries ago in preparing and in cooking food in some Asian and Mediterranean countries (12). Today, China is the top producer of rapeseed followed by Canada, which is the world's largest exporter of rapeseed oil.

The crushing of rapeseed produces two valuable products: 40% oil and a meal which contains close to 40% crude protein. The original use of the oil was for industrial purposes, primarily as a lubricant (10). Rapeseed oil was approved for human consumption recently (in 1958 in Canada) and today, it is being used in many countries for making margarine, for cooking, and as salad dressing. The wide acceptance of rapeseed oil for human consumption resulted from the success of breeding program to reduce erucic acid in the oil from 25-50% in the original varieties to less than 2% in the most recent varieties. Oil from varieties low in erucic acid has higher nutritional value and is refined at a lower cost (10). Rapeseed meal of the original varieties contained 1.5% glucosinolates, which reduced the efficiency of utilization of the meal fed to livestock and poultry. Therefore, rapeseed meal has not been readily accepted in the feed industry. Genes for low glucosinolate content were discovered by Krzymanski in the Polish variety Bronowski (10) which was used in breeding programs. By 1974, the first commercial variety of Canola (low in erucic acid and in glucosinolates) was licenced in Canada.

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The genus *Brassica* is represented by many wild and cultivated species. The present studies dealt with varieties of oilseed *Brassica sp.*, of which the oil is low in erucic acid and the meal is low in glucosinolate. They belong to two annual species, *B. napus,* commonly referred to as rape or Argentine rapeseed, and to *B. campestris,* commonly referred to as turnip rape or Polish rapeseed (10). The two species differ mainly in earliness; *B. campestris* varieties are earlier, and thus escape late drought, and they are shorter and more resistant to shattering at maturity (1). *B. campestris* is less sensitive to drought but it yields less, and has smaller seeds of a lower oil content (5).

Varieties belonging to both species, *napus* and *campestris,* were introduced and tested in Cyprus, mainly under rainfed conditions, in order to select varieties adapted to the climate of Cyprus and also be grown in rotation with barley.

Materials and Methods

Varieties were introduced from Australia, Yugoslavia, Sweden and Canada during the period 1983-85, and were evaluated mainly under rainfed conditions. The varieties were selected to be low in erucic acid and glucosinolates. As rapeseed was a completely new crop to Cyprus, information from other countries was used in deciding on sowing date, seed rate, and weed and disease control in the initial part of the work.

In an observation nursery, five sowing dates were compared, starting in November and following in monthly intervals until March. There were four replications sown in randomized complete blocks. Sowing was done by an experimental drill in November at seed rates ranging from 7.5 to 10 kg/ha, and sowing depth around 3 cm. Between-row spacing was 17.5 cm. Seedlings were thinned in the row to approximately 5 cm (110 plants/m^2). However, because of uneven emergence, the number of plants was around 20% lower in most cases. At sowing, 45 kg N and 50 kg P_2O_5 per ha were applied. In addition, 40 kg N/ha was top dressed in late January- early February (beginning of bolting). Insects were chemically controlled whenever necessary. Weeds were controlled by hand, mainly at the rosette stage (1-2 months after emergence).

At maturity (end of May) plots were harvested by hand or mower, sun dried and then fed to an experimental combine for threshing. Harvesting was done when the seeds were ripe but the stems still green, to avoid shattering.

Data were recorded on plant phenology, flowering date, plant height, grain yield, 1000 grain weight, volume weight, protein content (% N x 5.71) and oil content.

Most of the trials were grown under rainfed conditions where annual precipitation ranged from 288 to 487 mm (Table 1). Precipitation was unevenly distributed during the growing season, but in general the first affective rains came in November and increased in amount and frequency during December-February. Lower amounts were recorded in March-April and very little precipitation occurred in May. Supplementary irrigation (30-

80 mm) was provided in three of the 11 trials (Table 1) to maintain adequate soil moisture throughout the growing season.

Table 1. Grain yield (kg/ha) of the best rapeseed varieties: four *B. napus* and one *B.campestris* (Jumbuck).

	Year/name location of testing**											
	1983/4	1984/5				1985/6	1986/7		1987/8			
Variety	Athalassa	Dromolaxia	Sarantaskalon	Athlassa*	Morocambos	Zyghi*	Dromolaxia	Athlassa	Dromolaxia	Athlassa	Zyghi*	Mean 11 trials
Wesreo	2109 a	4484 ab	2812 ab	5750 a	1835 b	1770 a	3645 a	5923 a	3618 a	1345 a	4423 a	3429
Wesway	1791 a	3878 bc	3256 a	4847 a	2124 ab	2150 a	3697 a	5821 a	3696 a	1519 a	4761 a	3413
Wesroona	2324 a	4921 a	3078 a	2893 a	1879 b	2345 a	4335 a	4702 a	2426 bc	2031 a	4993 a	3266
Midas	1880 a	4536 ab	2945 ab	4780 a	2560 a	2211 a	3037 a	4954 a	2680 ab	1710 a	4655 a	3268
Jumbuck	2020 a	3596 c	2353 b	3522 a	1739 b	2048 a	3631 a	3615 b	1600 c	1331 a	2952 a	2583
CV (%)	34.0	14	15	45	18	23	28	21	22	42	11	
Precipitation (mm^2)	314	487	288	288	323	291	369	321	479	316	438	

* Irrigated. ** Values followed by the same letter are not significant at 5% level.

Results

Plant Growth

Following sowing in moist soil, emergence took place within 10-20 days depending on temperature. Because, unlike in cereals, the growing point of rapeseed is above the ground it is liable to injury. Indeed, in some cases significant damage (thinning) was caused through destruction of the growing point by birds. The young plants remained at the rosette stage for about 60 days, developing 3-6 leaves, during the cold winter months. At this stage, in addition to high seedling mortality, the young plants could not compete with the weeds, especially grasses.

After the rosette stage, the plants reached bolting stage by rapidly sending up their stem with a cluster of flower buds at the top. The time from emergence to bolting was influenced by species and temperature. *B. campestris* had shorter period than *B. napus*, but differences among varieties within species were negligible. After bolting, the plants grew fast, covered the soil, thereby eliminating weed competition, and soon reached flowering. *B. campestris* varieties flowered in the first 5-10 days of March and *B. napus* about 20 days later. Production of secondary, and lower order branches, and flowering continued and, in normal population densities, all the available space was filled. Rapeseed matured soon after barley (end of May) before soil moisture was exhausted.

Grain Yield

Grain yield varied with location and year, from 1.8 t/ha to 6.0 t/ha. Yield data are given for the five most promising varieties tested in 11 trials during 1983-88 (Table 1). Jumbuck belongs to *B. campestris* and the other varieties to *B. napus*. Three out of the 11 trials were given supplementary irrigation. In some rainfed trials with good rainfall distribution and high soil fertility, yield was comparable to that of irrigated trials.

The highest yielding varieties were Wesreo and Wesway (3.4 t/ha), followed by Wesroona and Midas (3.3 t/ha). The range of mean yield was

1.3-5.9 t/ha for Wesreo and 1.5-5.8 t/ha for Wesway (Table 1). The yield of Jumbuck was 2.6 t/ha, 24% lower than the yield of the best *B. napus* varieties Wesreo and Wesway. Tobin, another *B. campestris* variety, tested in 6 trials during 1986-88 gave an average yield of 2.55 t/ha, similar to that of Jumbuck (2.67 t/ha). Global, another promising variety, gave 3.9% and 7.2% lower yield than Wesroona and Wesway, respectively. Other promising B. napus varieties which gave slightly lower yield than the above varieties were: Altex, Pivot, Regent, Tobas, Westar, Niclas, Sv 002249, Sv 02221 and Wesbrook.

Flowering Date

In general *B. campestris* varieties flowered around 20 days earlier than *B. napus* varieties. All varieties tested flowered in March (Table 2). The mean flowering date of Jumbuck was the 2nd of March compared to 18-23 March for the *B. napus* varieties. Thus, flowering and grain filling were completed during March-April, a period during which there are still soil moisture reserves and, in addition, 40-70 mm rainfall. Variation in flowering date among years was small.

Table 2. Flowering date (1 = 1st February) of rapeseed varieties

	Year/number of locations*			
	1983/4	1984/5	1987/8	Weighted
Variety	1 loc.	2 loc.	3 loc.	mean
Wesreo	50	54 a	54 a	53.3
Wesway	54	53 a	53 a	53.2
Wesroona	51	45 b	49 b	48.0
Midas	54	50 ab	54 a	52.7
Jumbuck	38	29 c	29 e	30.5
CV (%)	-	8.9	4.8	

* Values followed by same letter one are significantly different.

Plant Height

Plants at maturity were generally tall, with a height of around 140 cm for Jumbuck (*B. campestris*) and 145-152 cm for the *B. napus* varieties (Table 3). Environment caused significant variation in height, which ranged from 110 cm at Dromolaxia in 1987 to 190 cm in an irrigated experiment at Zyghi in 1988. In general, rapeseed plants were taller than safflower or cereals grown in the same fields. Some lodging was observed at the later stages of maturity, but it did not affect yield.

Table 3. Plant height of rapeseed varieties (cm).

	Year/number of locations*				
	1983/4	1984/5	1986/7	1987/8	Weighted
Variety	1 loc.	1 loc.	2 loc.	3 loc.	mean
Wesreo	140 a	134 a	144 ab	168 a	152.3
Wesway	136 ab	134 a	146 ab	166 a	151.4
Wesroona	114 ac	131 a	146 ab	164 a	147.0
Midas	129 abc	138 a	132 b	162 ab	145.3
Jumbuck	118 bc	131 a	159 a	141 b	141.4
CV (%)	9.3	6.8	13.1	6.6	

* Values followed by same letters are not significantly.

1000 Grain Weight

The mean 1000-grain weight of the most promising varieties was 1.9-3.2 g (Table 4). The two *B. campestris* varieties had similar 1000-grain weight (around 3 g).

Table 4. 1000-grain weight of rapeseed varieties.

	Year/number of locations*					
	1983/4	1984/4	1985/4	1989/7	1987/8	Weighted mean
Variety	2 loc.	4 loc.	1 loc.	2 loc.	3 loc.	12 loc.
Wesreo	2.80 bc	3.17 c	2.50 a	2.40 b	2.9 a	2.9
Wesway	3.35 a	3.44 ab	3.00 a	3.00 a	3.0 a	3.2
Wesroona	3.00 b	3.30 bc	2.75 a	2.88 a	2.8 a	3.0
Midas	3.20 ab	3.55 a	3.00 a	2.88 a	3.1 a	3.2
Jumbuck	2.75 c	1.98 d	2.0 a	1.50 c	1.6 b	1.9
CV (%)	8.8	13.4	13.7	8.0	12.7	

* Values followed by same letter are not significantly

Tobas, Sv 002249 and Sv 02221 gave the lowest 1000-grain weight among the *B. napus* varieties. Environment, especially drought during grain filling, affected 1000-grain weight. In 1988 the mean

1000-grain weight for 11 varieties was 2.3 g in a dry site (Athalassa) but 2.6 and 2.9g in irrigated or high rainfall areas (Zyghi, Dromolaxia).

Volume Weight

Differences among varieties in Volume weight were small, around 3-5 percentage points.

The mean of the highest yielding varieties over 12 trials was 67-69 kg/hl (Table 5). There was no significant difference between *napus* and *campestris* varieties. Environmental influence on volume weight was small.

Table 5. Volume weight of rapeseed varieties (kg/hl)

	Year/number of locations					
	1983/ 4	1984/ 4	1985/ 4	1989/ 7	1987/ 8	Weighted mean
Variety	2 loc.	4 loc.	1 loc.	2 loc.	2 loc.	11 loc.
Wesreo	70 ab	68 b	62 a	68 ab	68 b	68
Wesway	71 a	69 a	68 a	69 a	69 a	69
Wesroona	68 b	67 c	62 b	69 a	69 a	68
Midas	68 b	66 d	67 a	67 b	67 b	67
Jumbuck	66 c	68 b	67 a	67 b	68 b	67
CV (%)	1.6	0.7	4.7	1.1	1.1	

* Values followed by same letter are not significantly.

Oil Content

Oil content varied with variety and environment, but the differences were small. For the highest yielding varieties, it varied from 37% to 41% (Table 6). Midas had the highest oil content. However, when all the varieties tested, including low yielding ones, were considered, the range in oil content was much wider, 34%-47% in 1987 (for 20 varieties) and 38%-44% in 1988 (for 11 varieties). For the same variety, oil content in different years varied by 3-5%.

The oil content of the two *B. campestris* varieties in 1987 was 37%, the mean of 20 varieties 40.5% and the range 34-47%. In 1988 the oil content of the two *campestris* varieties was 41% and 42%, and the mean of *napus* varieties 42.2%

Considering only the highest yielding varieties, oil content of Jumbuck was 38%, compared to 38-41% for the *napus* varieties (Table 6).

Table 6. Oil content of rapeseed varieties (percentage of dry matter).

	Year/number of locations					
	1983/ 4	1984/ 4	1985/ 4	1989/ 7	1987/ 8	Weighted mean
Variety	2 loc.	4 loc.	1 loc.	2 loc.	2 loc.	11 loc.
Wesreo	37 cd	39 a	36 a	38 ab	41 b	38
Wesway	36 cd	38 a	35 a	37 ab	38 c	37
Wesroona	38 bc	36 a	39 a	34 b	41 b	37
Midas	40 b	38 a	41 a	42 a	43 a	41
Jumbuck	41 a	35 a	35 a	37 ab	41 b	38
CV (%)	4.6	10.7	7.8	6.5	3.6	

* Values followed by same letter as not significantly

Crude Protein Content

The mean protein content of the high yielding varieties was 24%, with small differences among varieties, Table 7. The range of protein content in two trials in 1987 for 21 varieties was 22-26% and in 1988 for 11 varieties 19-25%.

Associations Among Traits

In the 1986-7 and 1987-8 trials, 20 and 11 varieties, respectively, were evaluated. Grain yield in 1988 was associated with late flowering at an irrigated site, Zyghi, and at a high rainfall site, Dromoloxia (Table 8). At Athalassa, where there was moisture stress during maturity, especially for the late varieties, the correlation between flowering date and yield was not significant. The correlations of grain yield with 1000-grain weight and plant height showed that tall varieties and varieties producing large seeds gave high grain yield. Correlations of yield with other traits were not significant.

Table 7. Crude protein content (N% x 5.71) of dry matter of rapeseed varieties.

	Year/number of locations*					Weighted
	1983/4	1984/5	1985/6	1986/7	1987/8	mean
Variety	2 loc.	3 loc.	1 loc.	2 loc.	2 loc.	10 loc.
Wesreo	23.5a	25.1a	20.0b	25.9a	24.2a	24.2
Wesway	26.4a	25.1a	21.9a	24.5ab	24.3a	24.8
Wesroona	23.5a	24.2ab	21.5ab	24.9ab	24.3a	23.0
Midas	26.0a	25.5a	21.0b	23.1b	23.7a	24.3
Jumbuck	25.5a	24.2ab	20.3b	23.3b	23.2b	23.7
CV(%)	11.4	5.1	5.3	4.1	4.7	

* Values followed by same letter are not signficantly different.

Table 8. Correlation coefficients between traits (N:33 to 80) of rapeseed varieties (20 in 1986-7, 11 in 1987-8).

	1986-7	1987-8		
	Athalassa	Dromolaxia	Athalassa	Zyghi
Grain yield x Numb. of plants	0.13	-	-	-
" Flowering date	-	0.49**	0.004	0.74**
" Plant height	-0.005	0.65**	0.55**	0.53**
" Volume weight	-0.29	0.11	-0.05	0.08
" 1000-grain weight	0.46	0.68**	0.07	0.66**
" Oil content	0.002	0.16	0.33	-
" Nitrogen content	-0.23	0.24	-0.07	-
Number of plants x Plant height	0.07	-	-	-
" Volume weight	0.32*	-	-	-
" 1000-grain weight	0.24	-	-	-
" Oil content	0.23	-	-	-
" Nitrogen content	0.09	-	-	-
Flowering date x Plant height	-	0.82**	0.34*	0.58**
" Volume weight	-	0.35*	0.09	-0.33
" 1000-grain weight	-	0.76**	0.68**	0.72**
" Oil content	-	0.40*	-0.04	-
" Nitrogen content	-	0.29	0.57**	-
Plant height x Volume weight	0.27	-0.30	0.47**	0.26
" 1000-grain weight	-0.18	0.77**	0.28	0.45**
" Oil content	-0.38	-0.71**	-0.25	-
" Nitrogen content	-0.05	0.24	0.27	-
Volume weight x 1000-grain weight	-0.22	0.005	0.18	-0.22
" Oil content	-0.52**	-0.71**	-0.83**	-
" Nitrogen content	0.27	-0.11	0.12	-
1000-grain weight x Oil content	0.35*	0.27	-0.08	-
" Nitrogen content	-0.26	0.09	0.42	-
Oil content x Nitrogen content	-0.19	-0.28	-0.15	-

*P = 0.05; **P = 0.01

Population Density

The actual number of plants per m^2 in the five spacings were 38, 69, 71, 93 and 130 at Athalassa, and 48,86, 102, 129 and 182 at Akhelia. The populations were similar in both varieties tested, *B. napus* var. Wesroona and *B. campestris* var. Jumbuck. The effects of these populations were not significant in any of the traits tested, namely grain yield, plant height, volume weight and 1000 grain weight.

The grain yield of Wesroona was higher than that of Jumbuck by 31% at Athalassa and by 30% at Akhelia. Differences among locations were significant. Yield at Athalassa and Akhelia was 3.2 and 3.6 t/ha, respectively, plant height 121 and 149 cm and 1000-grain weight 2.4 and 1.7 g.

At Akhelia, the number of plants was recorded twice, at the rosette stage and at maturity. Plant mortality over the two varieties was 7-11% at the low population densities (34 to 65 plants per m^2) and 13-14% at the high population densities (80 to 109 plants per m^2).

Discussion

Rapeseed can be grown in Cyprus under rainfed conditions or with supplementary irrigation. Yields of up to 5.0 t/ha were obtained even under rainfed conditions with 321 mm of well distributed rainfall as was the case in 1986-7. Yields were as low as 1.8 t/ha under unfavourable precipitation conditions. The yields obtained are among the highest reported under experimental conditions. Commercial yields in Canada and other countries are 1-2 t/ha. Thus, the varieties used and the agronomic practices employed have given excellent results under Cyprus conditions. With further research work on varieties and cultural practices, higher yields will be obtained. Optimum N fertilizer requirements in India were 60-75 kg N/ha (2). In Cyprus a uniform rate of 90 kg N/ha was applied.

The main advantage of rapeseed over the other oilseed crops (safflower, soybeans and sunflower) is that it can be grown rainfed. The growth cycle of the varieties tested was completed before drought set in late-spring. Barley, the most successful rainfed crop in Cyprus, matures at the same time as rapeseed.

However, there are some aspects of rapeseed varieties that need to be improved. Seedling mortality is higher than cereals because the growing point of rapeseed is above the ground and is exposed to damage from biotic and non-biotic factors. The desired stand can be obtained by increasing the seed rate accordingly. The second point of concern is the long period that the young plant remains in the rosette stage in the winter. Because of the very slow growth during this period, fast growing weeds, especially grasses, could smother the crop and thin it drastically. In some countries, weed infested stands at this stage are ploughed in the soil (9). Rapeseed competes very well with weeds after the rosette stage due to its fast growth after bolting stage. Competition by weeds at the rosette stage can be reduced by pre-emergence application of herbicides e.g. Trifluralin (1). However, damage by weeds could also be reduced significantly if varieties having faster early growth are developed.

Rapeseed growing is completely mechanized. However, losses at harvesting may be quite high (10%) because of shattering (4). Losses of seed at the cutter bar amounted to almost 90% of the total yield losses by combine harvesting. The main harvesting methods are: (a) swathing and threshing, (b) desiccation by chemicals and combining, and (c) direct combining. In Cyprus, the combine harvesters used for cereals can be used with some modifications to harvest rapeseed.

The present study showed that population densities from 38 to 182 plants per m^2 gave similar yields. Other studies gve similar results (optimum plant population around 30-60 plants/m^2). By adjusting secondary branching, rapeseed plants can compensate for low or high plant populations (9, 3). Even 8 plants per m^2 gave a worthwhile yield in some cases. In Canada 70-170 plants per m^2 are recommended. Seed rates are adjusted to soil conditions; lower seed rates are used on fallow than on stubble. The recommended seed rates vary from 7 to 12 kg/ha (1). Our trials, sown on a well prepared seedbed with 7.5-10 kg/ha, gave excellent stands and in most cases thinning was necessary at the seedling stage, to reduce the number of plants to 110/m^2.

The agronomic traits are comparable to those reported in other countries. In general, the plants were very tall (150 cm), produced small grains (1000-grain weight 2-3 g compared to 30-40 g for barley) and of high volume weight (67-69 kg/hl). The oil content was around 38% and crude protein content 24%. From the data of these studies, the expected yield is 3.5 t/ha of grain, from which 1.3 t/ha of oil and 2.2 t/ha meal rich in protein (40%) will be produced.

The best varieties were the *B. napus* varieties, which, though maturing later than *B. campestris* gave higher yield in most cases, on average 25% higher. *B. napus* produced larger grains but differences in other traits between the two species were small. The correlation coefficients between traits showed that the highest yielding varieties were late and tall, and produced large grains. This can aid future breeding programs.

It is concluded that rapeseed can be grown successfully in Cyprus. Yields are satisfactory even under rainfed conditions but with 1-2 irrigations in dry years, especially at the grain filling period, yields can be increased significantly. This crop can be grown in rotation with barley and any other rainfed or irrigated crop. The protein-rich meal can reduce soya meal imports. There is no possibility to export seeds of oil crops. Therefore, it is necessary for the seed to be processed locally.

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THE RAPESEED (*Brassica napus* L.) QUALITY BREEDING PROGRESS IN SHANGHAI ACADEMY OF AGRICULTURAL SCIENCES (SAAS) FOR RECENT YEARS

Sun Chaocai

Rapeseed (*Brassica napus* L.) is the main oil crop in the suburbs of Shanghai. Shanghai is one of the highest rapeseed producing regions in China. The rapeseed growing area has gradually increased and the seed yield is stable in recent years, Table 1. Our government began to pay great attention to study the improvement of rapeseed quality at the end of 1970.

Table 1. The rapeseed area and yield in Shanghai

Year	Area (ha)	Yield (kg/ha)
1981	63,730	2,047
1982	63,160	2,355
1983	52,750	1,785
1984	49,740	2,303
1985	70,670	2,010
1986	80,730	1,890
1987	80,000	2,099
1988	85,330	2,198

The rapeseed quality breeding program, which started in SAAS in 1981, has been supported by the Canadian International Development Research Centre (IDRC) since Oct. 1983. Three high-quality rapeseed strains have been developed and put in to Shanghai's and national region tests since 1983. With the development of new strains, the seed yield has increased gradually, Table 2.

Table 2. Change of yield among three high-quality rapeseed strains from 1983 to 1988

Strain	Time	Check ± %	Quality
2524	1983-1985	-(25-35)	0+
24016	1985-1987	-(15-25)	00
8701	1987-1988	+5-(-5)	0+

A single-low rapeseed strain has been put in both Shanghai's tests, national rapeseed variety region tests and production tests in 1989. Four-single low and two double-low rapeseed strains have entered the multi-location tests. Thirteen single-low and seven double-low strains have been placed in the strain yield tests. We are sure that more new strains, which possess better agronomic characters, quality and higher seed yield than the popularized varieties are being put in the Shanghai's or national region tests so that they become high-quality commercial varieties.

Virosis and Sclerotina in rapeseed are two main diseases which severely affect the seed yield and quality in the suburbs of Shanghai. Disease resistant rapeseed breeding started in SAAS in 1960's. With the development of the research on rapeseed quality breeding, disease resistant rapeseed breeding is more and more important for increasing seed yield and improving quality. It was in 1983 that SAAS started to screen and evaluate parent materials of rapeseed (*B. napus* L.) with virosis resistance. A total of 866 materials were inoculated artificially in the greenhouse and infected naturally in the fields for evaluation. Some resistant strains and plants have been obtained through selection and evaluation over several years; for example, "Xuan 35" and "81-23". The solid foundation has been laid for virosis resistant rapeseed breeding. SAAS cooperates with the University of Manitoba to screen and evaluate the resistance to Sclerotinia.

SAAS conducted research on rapeseed anther culture in 1985. The laboratory for rapeseed tissue culture has been set up with the financial aid from Canadian IDRC. The anther culture technique has been combined with the rapeseed quality breeding. Hybrid progenies of 39 different cross combinations have been anther-cultured for a few years. Five hundred fifty anther derived plantlets survived after transplant. They were doubled to diploid plants and normally set seeds. In autumn of 1988, 50 anther-derived materials were planted in hybrid nursery for field selection. More hybrid progenies are to be anther-cultured in 1989.

The cycle of frozen chamber vernalization, growth room, greenhouse and field has been set preliminarily and put into use. The first generation of 22 cross combinations passed vernalization in frozen chamber and produced seeds normally in the growth room in the summer of 1988. We have invented a good condition to speed up alteration of rapeseed generations and breeding.

As an important aspect of rapeseed quality breeding, it is necessary to enhance the precision of the quality assay technique. Under the financial aid from IDRC and the investment from our government, SAAS has set up a testing centre and a chemistry laboratory which can fit the rapeseed quality breeding. Several techniques for analysis on the main quality indices have been introduced, developed and studied in rapeseed. The centre and the laboratory have been equipped with 2 gas chromatographs, 1 nuclear magnetic resonance, 1 HPLC, 1 infrared spectrophometer, 1 high-speed cryocentrifuge and cryo-refrigerator, 1 KDM-01 nitrometer, 1 electronic analysis balance and other precision instruments. The preliminary and precise analyses procedures for erucic acid and glucosinolate have systematically been established. Study on modification of UV thiourea and of infrared spectrophotometric has been finished for the analysis of glucosinolate content in meal. TMS method has been studied and modified. Thymol method has been introduced. We cooperated with other Chinese institutions to study and fulfil the standard method of analysis of erucic acid content in oil; and held a few training courses on rapeseed quality analysis. Many technicians were trained with good result.

During Sino-Canadian rapeseed breeding project, Canadian IDRC offered scholarship for three M.Sc. pursuers from SAAS and accepted two visiting scholars. Three graduates are studying for Ph.D. in Canada. Canadian scientists sent by IDRC came to Shanghai to give lectures on rapeseed breeding, virosis and biological technique. Ninety one Chinese rapeseed breeders and technicians attended them. We also held training courses on rapeseed quality analysis and knowledge of designing field tests, observing and recording growth stages and agronomic characters of rapeseed varieties. Fourteen technicians engaged in rapeseed quality analysis and many technicians coming from the suburbs of Shanghai attended them. Owing to this foundation, we have established four places (including SAAS) for multi-location tests, three places for production tests, two places for performance tests and one place for stock seed production. A cycle from rapeseed breeding to production has preliminarily been formalized in Shanghai.

As we mentioned above, the rapeseed quality breeding in SAAS is stably put forward under the financial aid from Canadian IDRC and the investment from our government. We, here, would like to express our sincere appreciation to Canadian IDRC. We truly hope to enhance and develope the cooperation with Canadian IDRC and member countries of International Oil Crops Network in other fields of rapeseed improvement.

STATEMENT ON THE EXECUTION OF THE SINO-CANADIAN RAPESEED BREEDING PROJECT IN 1988

Wang Zao mu

The Sino-Canadian Rapeseed Breeding Project is executing the second stage of the second year. The second yearly meeting has been held in Urumqi, Xinjiang, China, and we warmly welcomed, many experts from home and abroad to our academy for inspecting and directing our works.

In the plan of the second stage of this project, the objectives of the rapeseed breeding program of Xinjiang Academy of Agricultural Sciences are:

a) to select and test some single-low or double-low varieties (or lines) of *Brassica juncea* which will adapt to Xinjiang and other spring rapeseed areas in China, and

b) to introduce and evaluate some double-low varieties of *B. campestris* and *B. napus* and single-low varieties of *B. juncea*.

Based on the objectives stated above, some progresses have been made in our academy in 1988, as follows:

I. Selection and Testing of Rapeseed Varieties or Lines

1) Regional Test of Low Erucic acid Varieties or lines of *B. juncea*

Since 1986, the regional test has been carried out in Xinjiang, and 1988 is the last year of the regional test. Moreover, a regional test of spring *B. juncea* in the northern part of China has been started this year. The test consists of 10 locations distributed in 6 provinces, including Inner-Mongolia, Gansu, Qinghai, Shanxi, Hebei and Xinjiang provinces or autonomous regions. One of the 10 locations is Anningqu experimental farm where our honorable representatives have taken an investigation in the field. The results of the regional test with 5 varieties or lines and 8 locations which was carried out within Xinjiang in 1987 to 1988 are summarized here.

a) Yield: According to the average yield over the 8 locations, the rank of the 5 tested varieties or lines in in Table 1.

Table 1. Yield of low-erucic lines and a check over 8 locations in the regional test.

Variety (or line)	Yield (t/ha)	Compared with ck (%)	rank
85-1312	2.85	+2.60	1
85-991	2.64	-4.90	3
Xin-you No.1(ck)	2.78	-	2
85-1026	2.25	-18.97	5
85-875	2.39	-14.00	4

Variety 85-1312 had the highest yield of 2849.1 kg/ha which exceeded the check by 2.6%. The check variety Xin-you No. 1 ranks second, its yield being 2776.8 kg/ha. However, the other 3 low erucic acid lines performed less than the check with regard to yield. Varieties 85-991, 85-875 and 85-1026 rank third, fourth and fifth, respectively. Their yields are 2640, 2387.55 and 2250.15 kg/ha which were less than the check by 4.9%, 14% and 18.9%, respectively. The yield of 85-1312 exceeded that of the check in 6 of the 8 locations. With a range of 3.63 - 30.34%. The yield of 85-991 exceeded in 3 locations with a range of 0.21 - 14.28%. The yield of 85-875 exceeded that of the check by 9.17% only in Zhaosu. The yield of 85-1026 was less than of the check in all locations.

The analysis of variance, (Table 2) indicates that differences between varieties, locations, and locations x years were highly significant.

Table 2. Mean squares of the different sources of variation

Source of variation	df	MS
V	4	19.66**
L	7	200.45
Y	1	2.96
VL	28	2.54
VL	4	3.25
LY	7	43.04
Error	28	1.36
Total	79	

** Significant at .01.

In order to further know the significance of difference among varieties, a multiple comparison among varieties was made, Table 3. There were 320 original data of 5 varieties (or lines) in 8 regional tested locations in 2 years. The result of the analysis shows that 85-1312 was highly and significantlly different from 85-1026 and 85-875; and Xin-you No. 1 from 85-1026 and 85-875; and 85-991; from 85-1026. Even there are differences in yield among 85-1312, Xin-you No.1 and 85-991, but their differences were not significant. The differences among the 8 locations except Changji and Mulei counties were highly significant. This shows that the selection of these locations was reasonable.

b) Quality: The analytical results of the fatty acid components and oil contents of the 5 lines indicated that in low erucic acid lines, the relative contents of oleic and linoleic acids increased dramatically as erucic acid almost diminished, Table 4. For example, the relative ratio of oleic acid in 85-991 exceeded that of Xin-you No.1 by 22.78%, and that of linoleic acid by 8.7%, which would considerably improve the nutritive value of rapeseed.

Table 3. Multiple comparison among varieties in two years

Variety	Yield g/plant*
85-1312	12.68a
Xin-you No. 1	12.24a
85-991	11.74a
85-875	10.58b
85-1026	10.06b

* Yields followed by same letter are not significantly different at .01 level.

Table 4. Fatty acid compositions and oil contents of the 5 lines (%)

	Variety/line				
Fatty acid	85-1312	85-991	Xin-you No.1	85-1026	85-875
Palmitic	5.72	6.03	4.74	5.44	6.23
Stearic	0.06	-	0.26	0.24	-
Oleic	42.82	46.85	24.07	38.75	41.03
Linoleic	33.37	34.15	25.45	38.91	34.54
Linolenic	15.44	11.66	12.81	14.67	14.96
Eicosenoic	2.07	0.83	12.04	1.08	2.67
Erucic	0.52	0.48	20.63	0.89	0.57
Oil content	37.68	37.36	37.03	37.24	35.67

c) Growth period: From the experimental data of growth period of the 5 lines grown in the 8 locations, it was found that the mean growth periods of the 4 low erucic acid lines were 4-8 days less than that of the check, Table 5. In some locations, the difference was upto 10 - 15 days. These low erucic acid lines were all developed through several times of propagation and selection (i.e., the offspring of a cross were grown and selected 2 times in the north and south sites in a year, by which the breeding program was speeded up). This resulted in growth periods shorter than their parents'. In general, short growth period tends to give low yield. However, they may be used as a substitute for *B.campestris* in some areas. On the other hand, to keep rapeseed from high temperature in hot summer and aphid damage, earliness is also needed.

Table 5. Days from sowing to ripening

	Variety/line				
Location	85-1312	85-991	Xin-you No.1	85-1026	85-875
Tacheng	93	90	95	91	93
Baicheng	118	116	121	116	118
Zhaosu	125	120	135	123	127
Anninqu	89	84	92	84	88
Qitai	92	90	94	93	92
Mulei	85	79	86	81	85
Jimusaer	108	101	110	106	105
Fukang	89	86	92	88	89
Changji	84	80	95	80	84
Mean	98	94	102	96	98

d) Major agronomic characters: The heights of low erucic acid lines measured less than that of the check, Table 6, which is beneficial for production. The number of effective primary branches plays a decisive role in single plant productivity, and has strong hereditary capacity. The major characters of yield components of 85-1312 were more than those of the check, and its yield ranked first among the 5 lines. However, 85-991 yielded less than the check due to its fewer seeds per siliqua, less 1000 seed weight and seed yield per plant.

Through a 2-year rapeseed regional test and quality analysis, the yield of 85-1312 exceeded the check Xin-you No. 1 by 2.6% and it increased in 6 locations out of 8 locations (3.63 - 30.34%). Variety 85-1312 has middle plant height, more branches, even growth, dense siliquae, lodging resistance, tolerance to white rust and *Peronospora parasitica*; and ripens 2-5 days earlier than the check. It has good quality with erucic acid content of 0 - 0.52%, and linoleic + linolenic acid contents of 77.28% (over the check Xin-you No.1 by 28.91%). Its oil content is over the check by 0.65%. So, it is a promising line with high-yield and good quality.

Variety 85-991 was not significantly different from the check based on their yields. Its major characters are: early maturity, good quality, growth period between 79 and 120 days, it generally ripens 7 - 15 days earlier than Xin-you No.1, and suitable to be grown in cold areas. So, it may be used to replace *B.campestris* or be adapted to multiple cultivation systems. Its erucic acid content is 0-0.48%. Its linoleic, linolenic and oil contents are over the check Xin-you No.1 by 22.78%, 8.7% and 0.33%, respectively. Its nutritive value is obviously higher than the check. It is a promising line.

The yields of 85-1026 and 85-875 are lower than the check, their other characters perform general.

Table 6. Agronomic characters of the 5 lines

Variety (or line)	Height (cm)	No. of Primary branches/plant	No. of Siliquae/ plant	No. of seeds/ Siliqua	1000-seed weight (g)	Seed yield (g/plant)
85-1312	181.8	6.4	329.5	18.6	3.02	13.8
85-991	154.3	5.6	319.9	17.6	3.01	12.0
Xin-you No.1	190.1	5.8	387.5	17.8	3.15	12.5
85-1026	178.6	4.7	365.2	16.8	3.01	11.6
85-875	171.4	4.7	293.3	16.8	2.75	10.5

2) Strain comparative test

A comparative test for low erucic acid lines was employed by adopting a randomized design with 3 replicates, 7 lines, $6m^2$ per plot and Xin-you No.1 was used as a check. All low erucic acid lines performed well. Among them, 87-885 (4122.0 kg/ha) ranked first exceeding the check by 23.34%. Variety 87-857-2 (3504.0 kg/ha) ranked second exceeding the check by 4.85%, and yields of other lines were lower than the check.

3) Hybrid progeny

In 1988, 166 materials were planted in a hybrid nursery and 626 offspring lines were planted in a selective nursery. These mostly descended from back-crossing and composite-crossing. They were used for the improvement of agronomic characters as good quality was considered first. At the same time, 30 new hybrid combinations were made and *B.juncea* cross with *B.napus* and *B. campestris* and their progenies were also back-crossed to increase their productivity and to improve their quality as well.

4) Germplasm resources (or parent materials)

In 1988, 235 collections were sown. Among these, about 148 materials were collected from abroad. However, there were no low-glucosinolate resources. This is one of the main problems for the breeding of double-low varieties.

II. Introduction and Evaluation

When Dr. R.K. Downey from Canada, Dr. G.Ohlsson from Sweden and Dr. J. Morice from France visited Xinjiang in July 1986, they offered a group of valuable materials including Topas (double-low spring rapeseed with high protein content), Line (double-zero variety) and Wesbrook (double-low spring rapeseed) of *B.napus* and Tobin (*B.campestris*), which were already used as parents in crosses and from which the progenies showed high degree of vigor. This year, 115 varieties or lines including 93 spring rapeseed varieties of *B.juncea*, 19 spring rapeseed varieties of *B.napus*, are *B.campestris* and two *B.carinata* offered by Dr.J.Morice were grown. They all have a proper adaptation to Xinjiang's climate. But some of them showed good economic characters and may be adopted as parents in the breeding program. Their quality is now under analysis.

Acknowledgement

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A PRELIMINARY STUDY ON THE COMBINING ABILITY AND HERITABILITY OF MAIN AGRONOMIC CHARACTERS IN *B. JUNCEA*

Wang Zao mu and Wang yan fei

Abstract

Combining ability and heritability of main characters of 11 diverse varieties were evaluated. General combining ability of main characters in Southerner and Zeme-1 was higher, but lower in Xin - you No 1 and Stock. The analysis of variance ratio for population combining ability showed the additive function of genetic variation in the characters of primary branches, branching height, main shoot length, etc... was dominant, but for siliquae per plant and secondary branches, the non-additive function was dominant. Narrow sense heritability was important in descending order for main shoot length, siliquae density siliquae length, branching height, siliquae per plant secondary branches and primary branches. The heritability of first four characters was higher, which could be chosen from early generations.

In recent years, Chinese scholars proceeded with some studies on heritability and genetic advance of main agronomic characters in B. napus. In this study, 6 x 5 incomplete diallel cross was made up with rapeseed varieties of B. juncea so as to find out better hybrid parents and determine characters and select generations.

Materials and Methods

In 1982 six rapeseed varieties introduced from abroad (Southerner, Yellow seed-230 from USSR, Zeme-1, Zeme-2 from Australia; Stock from France; Secus from Fedral Republic of Germany and five local varieties (strains) of *B. juncea* (Yili yellow, Xin you No. 1,548, 707, 624) were used and 30 combinations were made up according to two groups of parental incomplete diallel cross. In 1983, these varieties were planted in Anning qu experimental farm of Xinjiang Academy of Agricultural Sciences, in a random block design with three replications and three rows. Five plants were randomly chosen from the central row as testing samples. Parents were planted for observation. All of the testing materials grew normally and were harvested on July 23. Statistical analysis of the data was done according to (1).

Results and Discussion

I. Variance analysis of genotype

Table 1 shows the results of variance analysis on a per plant basis. Thirteen characters in model I are highly significant and 7 characters in model II are significant or highly significant. The result indicated significant difference among genotypes for these characters.

II. Analysis of general combining ability of the parental characters

Tables 1 and 2 show that:

1. There was significant difference in general combining ability of most characters of parental groups from abroad. For local parental groups, four main agronomic characters (siliqua on main shoot, seed yield per plant, seeds per siliqua, 1000-seed weight) showed no significant differences among varieties.

2. For the effect value difference of general combining ability, branching height was the greatest, followed by siliquae per plant, siliquae density and seed weight per plant, among parental groups from abroad. The difference value was in

Table 1. Analysis of variance of random block and of combining ability

Character	Genotype model I	Genotype model II	Local parent groups model I	Local parent groups model II	Foreign parent groups model I	Foreign parent groups model II	Local x foreign
D.F.	29	29	4	4	5	5	20
Silique on main shoot	2.19**	1.36	1.90		6.22**		
Seed yield per plant	4.35**	1.34	1.36		6.02**		
Seeds per silique	2.70**	1.59	2.34		8.20**		
Silique per plant	4.24**	1.74*	3.20*	0.90	7.81**	2.19	3.56**
Plant height	5.88**	1.57	6.63**		9.33**		
Primary branches	2.62**	1.74*	3.94**	2.69*	6.21**	4.25*	1.46
Branching height	14.95**	4.92**	15.89**	2.00	42.71**	5.30**	7.95**
Main shoot length	7.02**	4.51**	3.23*	1.30	28.30**	11.46**	2.47**
Secondary branches	4.99**	1.76	3.70**	0.89	9.53**	2.30*	4.14**
Silique density	5.69**	3.41**	3.00*	1.50	24.90**	12.44**	2.0**
Silique length	7.86**	5.35**	13.41**	3.97**	21.14**	6.26**	3.38**
Stem diameter	4.04**	1.50	6.36**		2.12		
1000-seed weight	3.44**	1.43	1.17		7.50**		

* Significant at P = 0.05

** Highly significant at P = 0.01

Table 2. Relative effect value of general combining ability

Parents	Silique on main shoot*	Seed yield/ plant*	Seeds per silique*	1000-seed weight*	Silique per plant	Plant hei.	Primary bran-ches	Branch-ing hei.	Main shoot len.	Second-ary branches	Siliq-uae den.	Siliq-uae len.	Stem diameter**
Southerner	8.3	5.4	-4.2	6.06	2.30	3.30	-2.8	6.90	11.30	-6.7	0.5	2.7	
Secus	3.5	-6.8	-6.9	0.38	-6.50	1.70	7.9	22.2	-10.50	0.0	17.5	-9.0	
Yellow seed-230	1.03	0.6	-0.13	0.76	0.55	0.48	-2.8	4.80	10.30	1.4	-10.0	0.3	
Zeme-1	-3.1	11.1	-3.2	0.76	13.20	-1.20	7.8	-22	2.30	15.2	-5.0	-0.3	
Zeme-2	-3.9	5.6	4.3	-1.52	5.05	-0.16	-4.8	-17.9	0.96	-3.1	-6.3	0.5	
Stock	-5.8	-15.9	3.6	-5.3	-14.7	-4.1	-4.8	5.7	-14.4	-6.7	11.3	6.4	
548					-1.07	1.8	-2.8	-8.2	4.6	-3.8	-3.8	5.1	6.6
707					-2.94	1.7	2.1	12.1	-0.8	-3.1	6.3	2.1	-2.1
Xin you No-1					-0.99	-2.20	-5.4	-0.27	-4.40	2.4	1.3	-4.5	2.3
Yili yellow					9.70	-2.00	6.1	-9.80	-0.24	7.3	0.0	-0.3	-2.1
624					-4.70	0.80	0.3	6.10	0.88	-2.4	-2.5	-1.9	-3.6

* Because the differences among varieties of the local parent groups is not significant, data are neglected.

** " " " " " " " foreign " " " " " " "

the order of 44.2, 27.9, 27.5 and 27.0. Among local parental groups, branching height, siliquae per plant, primary branches and secondary branches gave difference value in the order of 21.9, 14.4, 11.5 and 11.1.

3. The parents from abroad, such as 'Southerner' characteristics of siliquae on the main shoot, plant height, main shoot length and 1000-seed weight; 'Secus' characteristics of primary branches, branching height and siliquae density; and 'Zeme-1' characteristics of seed yield per plant, siliquae per plant and secondary branches etc... were higher in general combining ability. But all the characters of 'Stock' had lower combining ability. Among the local parents, '548' characteristics of plant height, main shoot length, siliquae length and stem diameter; and 'Yili yellow' characteristics of siliquae per plant, primary branches and secondary branches, had higher

general combining ability. The general combining ability of all characters for 'Xin you No. 1' was lower.

III. Analysis of specific combining ability

Table 3 shows that the relative effect value of specific combining ability was the highest for seed yield per plant, siliquae per plant, siliquae density, and stem diameter of the combination (Southerner x 548). But, those whose specific combining ability was the strongest were not sure to have the strongest heterosis. Being simultaneously affected by general combining abilities, only those combinations that were higher in the effects of specific and general combining ability could give the strongest heterosis.

In this test, seed yield per plant of the combination (Southerner x 548) was the best; siliquae per plant of the combination (Zeme-1 x Yili yellow) was the best, main shoot length of the combination (Yellow seed-230 x Yili yellow) was the best; and secondary branches of the combination (Secus x 624) was the best.

IV. Relative ratio of variance for population combining ability

Seven characters, according to model II, were significant with the analysis of variance for combining ability and accordingly, the relative ratio of variance for population combining ability was estimated, Table 4. The variance ratio of general combining ability of the five characters was significantly greater than that of specific combining ability of the primary branches, branching height, main shoot length, siliquae density and siliquae length, which showed that genetic variation of these characters resulted mainly from the variance of general combining ability, that is, additive effects dominated the heredity. So, according to the selection of general combining ability for parents, these characters could be improved. The variance ratio of specific combining ability was greater than that of general combining ability. In siliquae per plant and secondary branches, variance ratio was in the order of 76.5 and 76.0. This result showed that the function of the non additive effect of these characters dominated the formation of hybrid characters which in turn made the selection of combinations more important in breeding.

V. Estimation of heritability

Broad sense heritability h_5^2) and narrow sense heritability (h_{11}^2) of seven characters estimated are presented in Table 5. The result showed that the h_5^2 was significantly and greater than h_{11}^2. The greatness and smallness of narrow sense heritability of each character were in regular order: main shoot length, siliquae density, siliquae length, branching height, siliquae per plant, secondary branches and primary branches. As the variation of the characters was slightly affected by the environment, the heritability of the first four characters was a little higher. The heritability of primary branches, secondary branches and siliquae per plant which were affected by the environment was a little lower.

Judged by the difference between h_5^2 and h_{11}^2 the difference in primary branches and secondary branches was greater, showing that the non additive function was dominant. The difference in other characters was less showing that the additive function was dominant.

It was estimated that the characters with higher heritability, such as branching height, main shoot, etc... could be selected from early generations. Characters with lower heritability, such as primary branches, etc. should be selected from later generations.

Table 3. Relative effect value of specific combining ability

	COMBINATIONS*														
	Sn	Sn	Sn	Sn	Sn	S	S	S	S	S	Y	Y	Y	Y	Y
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Characters	548	707	X	Yi	624	548	707	X	Yi	624	548	707	X	Yi	624
Seed yield/plant	12	-7.5	1.49	-16.8	-22.5	10.9	-8.2	-9.6	-4.2	10.9	8.9	1.2	9.4	2.7	-22.3
Siliquae/plant	25.1	-17.2	12.3	-9.1	-11	5.7	-11	-8.3	-5.5	19	-10.5	-11.6	15.3	4.7	2.1
Plant height	1.02	0.05	1.4	-4.5	-1.9	2.9	4.2	-2.5	-1.4	-3.3	-4.7	6.4	3.77	-0.86	-4.8
Branching height	3.0	4.5	-6.5	-3.4	9.6	-9.0	20.6	-2.6	4.7	13.7	1.4	-26.9	2.0	-7.9	-22
Main shoot length	-9.2	5.5	7.6	-3.5	-0.4	6.9	-5.1	0.9	-7.7	5.5	4.3	-6.8	1.7	10.0	-0.6
Secondary branches	14.9	-3.3	0.36	-9.1	-4.9	-5.6	-1.8	-10.9	-8.6	26.4	2.9	-20.5	7.6	6.2	3.3
Siliquae density	13.8	-3.8	-10.0	-1.3	1.3	-1.3	3.8	-5.0	6.3	-3.8	6.3	2.5	-1.3	-3.8	-5.0
Siliquae length	2.9	-0.8	7.7	1.3	-3.2	-1.1	-1.3	1.3	-5.3	5.3	2.9	-2.7	2.1	-2.9	0
Stem diameter	22.6	-15.4	-1.5	-5.2	-0.8	-1.5	8.7	-6.6	4.3	-6.6	-9.6	5.8	6.5	-4.5	-0.8
1000-seed weight	1.14	1.52	7.58	-10.2	1.14	5.3	-2.65	-4.55	-3.79	4.35	0.76	4.17	-1.52	-1.52	-1.89

Table 3. Contd.

	Z_1	Z_1	Z_1	Z_1	Z_1	Z_2	Z_2	Z_2	Z_2	Z_2	St	St	St	St	St
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Characters	548	707	X	Yi	624	548	707	X	Yi	624	548	707	X	Yi	624
Seed yield/plant	-31.2	-9.4	19.7	7.6	13.2	4.4	8.1	-13.4	6.5	-5.7	-25	15.9	-21	4.1	26.3
Siliquae/plant	-5.27	6.67	-2.0	16.2	-15.6	2.26	13.4	-3.8	-6.5	-5.3	-17.3	19.7	-13.5	0.2	10.9
Plant height	-0.96	-5.4	-1.1	0.43	7.1	3.3	-2.1	0.27	2.8	-4.4	-1.7	-3.2	-2.2	3.5	3.5
Branching height	0.27	-20.9	4.9	-18.4	34.0	4.7	-8.7	-6.7	17.7	-6.7	6.3	-21.8	9.2	7.3	-0.5
Main shoot length	-1.9	5.9	-11.1	3.0	4.2	6.5	-4.2	-0.08	5.7	-8.0	2.1	4.5	1.0	-7.5	-0.1
Secondary branches	-1.8	10.1	1.1	0.6	-10.5	4.7	4.9	3.1	7.3	-4.9	-15.2	10.3	4.2	18.0	-9.4
Siliquae density	-6.3	-3.8	11.3	-8.8	6.3	-2.5	1.3	-3.8	0	1.3	-10.0	-5.0	5.0	6.3	0
Siliquae length	1.1	1.6	-7.7	3.7	0.8	-1.6	2.4	1.6	-3.7	0.8	1.1	0.53	-6.4	9.0	-4.8
Stem diameter	-0.07	-1.5	4.3	-2.3	-1.5	-0.8	-3.0	-3.0	2.1	3.6	-13.2	2.8	1.4	3.6	3.6
1000 seed weight	-8.33	0.38	-1.89	8.7	0	2.65	-1.14	0.38	3.41	-6.44	-1.52	0.76	1.52	-1.14	1.14

* Sn=Southerner, X=Xin you No. 1 Yi=Yili yellow, S=Secue, Y=Yellow seed-230, Z_1=Zeme-1, Z_2=Zame-2, St=Stock

Table 4. Variance ratio for population combining ability (%)

Item	Siliquae per plant	Primary branches	Branching height	Main shoot length	Secondary branches	Siliquae density	Siliquae length
Variance for g.c.a	23.5	74.6	54.0	78.3	21.0	82.6	68.7
Variance for s.c.a	76.5	25.4	46.0	21.7	76.0	17.4	31.3

Table 5. Estimation of heritability (%)

Estimate	Branching height	Siliquae length	Main shoot length	Siliquae density	Secondary branches	Primary branches	Siliquae per plant
h_S^2	93.8	88.4	87.1	82.1	80.5	71.7	64.6
h_{11}^2	50.7	60.7	68.2	67.9	19.4	18.1	48.1

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REPORT ON THE EXECUTION OF SINO-CANADA RESEARCH BREEDING PROJECT

Liu Cheng Quing and Hong Hai Ping

The Institute of Oil Crops Research of China Academy of Agriculture and Quinghai Academy of Agriculture Sciences are two of the four co-operated Institutes in Sino-Canada Rapeseed Breeding Project. Meanwhile, we have been carrying on the key projects in China on the sixth and seventh five-year plans, since good-quality rapeseed breeding became our country's key project. We have also been supported by IDRC for two periods with finance, equipment and technology. Owing to the bilateral effort by China and Canada, the good-quality rapeseed breeding project has made great progress. Both China and Canada are satisfied with the result.

A. Screening and evaluating good parental lines

The collection and evaluation of parent materials is an important aspect of the study in Sino-Canada rapeseed breeding project. Since 1983, we have screened and evaluated more than 280 materials of *B. napus* and 210 materials of *B. campestris*, and from these we have selected some good parent materials for the breeding study.

1. After several years of selfing, we have selected a lot of parental lines with different maturity times, good quality characters, single-low, double-low, oil content - above 45% and linoleic acid content- about 35%.

2. After several years of natural field evaluation and partly of greenhouse artificial inoculation, we selected several varieties (lines) that are tolerant to *Sclerotinia*, such as 81007, 81006, 84004 and Start, which are double-low or single-low varieties. Some of these can also resist virus. Nowadays, we have got preliminary results to use them in crossing programs. Among these, 84004 and 821 have the strongest disease tolerance and heritability. We used them as parents and crossing progenies have higher disease tolerance. The reciprocal cross was different as tolerance to *Sclerotina* is influenced by the female.

B. Double-and single-low varieties

We have begun breeding rapeseed for quality since the end of 1970. Under the financial aid from IDRC, we have bred six single-and double-low rapeseed varieties and used them in rapeseed production. They filled the gap of our country's good quality rapeseed demand.

1. Within a few years, Quinghai Academy of Agricultural Sciences introduced, selected and developed good-quality varieties such as Oro, Tower, Westar from Canada, and Topas from Sweden. These varieties have been planted on large-scale in northwest and northeast parts of China. Among these, Oro covered 800,000 ha, Tower 133,333 ha, Westar 66,667 ha, Regent 33,333 ha and Topas 13,333 ha. Next year, these areas will be increased. In addition, the QAAS has bred double-and single-low *B. campestris* varieties (lines) such as 82 C 11-4, 82 C1, 83-81 which are used in cold and high altitude areas. Varieties 83-109 and 86027 appeared to be very good in the northern rapeseed

testing region. Next year, they will ecome registered varieties.

2. The Institute of Oil Crops Research in China Academy of Agricultural Sciences has bred six single- and double-low rapeseed varieties (lines) of *B. napus* which have been put into rapeseed production in the region of the Yangze river:

   i) In 1986, three single-low and winter-form rapeseed varieties of *B.napus* have finished their test and became normal varieties. Zhong you 1 and 2 were widely developed in the middle region of Yangze (Hubei, Hunan, Jiangxi, Anhui). The total rapeseed area was 46,667 ha. The average rapeseed yield was 1350 - 2023 kg/ha. It increased by 5-12% than those of the local varieties Zhong You 2 single-low appeared more tolerant to *Sclerotinia* than those of the local double-high improved vareties up to now.

   Zhong You 3 single-low which became a good quality variety with yield higher than that of the double-high varieties. It is an early maturing winter variety. Its seed yield is 1800-2700 kg/ha and is 14-23% higher than that of the local double-high varieties. It suits a type of rice rice-rapeseed rotation in a year. It appears very well in He Zi Zou Lang of Gansu province. Nowadays, it occupies 4000 ha. Yunnan, Sichuan and Gueizhou planted larger area.

   ii) Three double - low winter rapeseed varieties (lines) were bred in 1988. The erucic acid content of the double-low line 84001 is 0.32% and its glucosinolate content is 14.36 - 21.02 umol/g. The seed yield equaled that of the local double-high varieties. The average seed yield of 36 places in Yunnan province was 2407 - 2979 kg/ha from 1986 to 1987. The seed yield was 18.3 - 22% higher than that of Zhong You 3 single-low, 23-25.1% higher than that of double-high variety "Yun You 31". In 1987-88, it was planted on 733 ha and the average seed yield was 2414.55 kg/ha in spring of 1989, it will be developed to suit tri-rotation in a year.

   Erucic acid content of the double - low 84039 is 0.5%, glucosinolate content is 16.52 - 22.3 umol/g, and oil content is 42.4 - 43%. Through a three-year regional testing in the middle region of the Yangze river, the seed yield equaled that of the local double-high varieties (average 1447.5 kg/ha). It is the best good-quality rapeseed variety in the middle region of the Yangze river. We planted 333 ha in Jian county of Jiangxi province in 1987. The average seed yield was 3.2 - 14.1% higher than that of the local double-high varieties "Xinan 302". It can be widely grown in spring of 1989, and it suits tri-rotation with rice, but it is not tolerant to *Sclerotinia*.

   The erucic acid content of the double - low 84004 is 0.31%, its glucosinolate content is 13.27 - 21.45 umol/g and its oil content is 43.2%. The seed yield in the regional test in Hubai and Anhuei provinces was the same as that of local double-low varieties. But the seed yield of the large-scale rapeseed production increased and reached significant level. Average seed yield of 252.3 ha test planted in Guchang country of Hubei province from 1986 to 1987 was 2298 kg/ha. The area under this variety increased to 600 ha in 1987-88 and although during flowering it met an abnormal climate, it yielded 15.7% higher than that of double - high varieties. The average seed yield was 1350 kg/ha. In this area, the average seed yield of 62.3 ha was 2310 kg/ha and was the highest one. In 1988, 84004 was planted on 2333 ha in this county. The seed yield in Zhecheng county of Hubei province was 3750 kg/ha which was the highest in this year than before. It also appeared hardly resistant/tolerant to *Sclerotinia* and virus. Varieties 84004 and 821 were artificially inoculated with *Sclerotinia* for six times in greenhouse and were evaluated. The result showed that 821 was more tolerant to *Sclerotinia* than the double-high variety (Gan You 5), at 5% significance level. It was also hardly resistant/tolerant to virus. We are sure that 821 is one of the best double low-varieties (lines) for disease tolerance in Hubei.

Besides these, our two institutes selected a number of double - low lines for disease tolerance and also put them in the third regional test.

C. Establishing systematic analysis techniques to fit rapeseed breeding

With the financial aid from IDRC, the rapid and precise analyses of erucic acid, glucosinolate and oil content have been established and we gained a lot of equipments in recent year. According to Chinese status, few rapid analyses of erucic acid and glucosinolate were improved and some simple instruments were made.

D. Training

With the financial aid from IDRC, we have cooperated with other institutions to train several persons for Degrees abroad and 120 technicians for rapeseed breeding, introducing varieties, regional test and quality analysis at home. These trained technicians are playing an important role in enhancing the research on quality rapeseed breeding and popularizing modern techniques in China.

A REVIEW OF OROBANCHE PROBLEM IN NEPAL

M.L. Jayaswal

Abstract

Orbanche is a serious root parasite of Brassica oil crops and tobacco in Nepal. *Orbanche aegyptiaca* is the predominant species particularly on Brassica oil crops. However, *O. ramosa, O. caerulescence, O. cernua, O. solmsii* also occur on different crop species.

A superimposed experiment in 1979/1980 indicated abut 20% yield loss due to Orobanche on *B. campestris* var. Toria. Soil solarization experiment conducted in 1980-1981 showed that soils covered by polyethylene sheet for 4-5 weeks prior to Toria seeding had significant reduction in Orobanche population. Another experiment conducted in 1987/1988 with nitrogen doses (0,30,60 kg N/ha and P & K constant @40 and 20 kg/ha, respectively) indicated that higher Orobanche population (39-42/m^2) was found in fertilized plots than in unfertilized plots (34/m^2). Reduction in seed yield of Toria due to Orbanche was less in fertilized plots (6.6-7.6%) than in unfertilized plots (16.3%).

It has been observed that Toria grown after maize or jute has high level of Orobanche than Toria grown after paddy rice. Also, higher infestation has been observed on *B. campestris* than *B. juncea*.

Orobanche (Broomrape) is a serious root parasite of many agricultural crops in the world, causing considerable yield losses to the host crop. About 140 species of *Orobanche* are reported to exist in the world.

In Nepal, Orobanche is found on many other crops, but Brassica oil crops (Toria, Sarson and Rai) and tobacco are the major hosts of economic importance.

Orobanche Species In Nepal And Its Distribution

Orobanche aegyptiaca is the predominant sp. particularly on Brassica oil crops. *O. caerulescence, O. cernua, O. alba* and *O. solmsii* are also reported to occur in Nepal. About three fourth of the total area under Brassica oil crops is in Tarai and inner Tarai regions.

Similarly, tobacco is mainly grown in Tarai region of the country. Therefore, a survey of *Orobanche* occurrence was carried out in January 1988 in Tarai, innertarai and some Mid-hill areas. Details of the observations are presented in appendix-1 and Figure 1.

The survey team consisted of the following members:

1. Vasudeo Rao, M.J., Plant Breeder (Groundnut), ICRISAT Centre, Patancheru 502 324, A.P., India.
2. Jayaswal, M.L., Co-ordinator, National Oilseed Development Program, Nawalpur, Sarlahi, Nepal.
3. Ranjit, Jagat Devi, Assistant Agronomist, Agronomy Division, Khumaltar, Lalitpur, Nepal.

This survey was sponsored by IDRC through South Asia Regional Office in New Delhi, India.

Host-Range of Orobanche In Nepal

During the survey trip, *O. aegyptiaca* (1) and *O. solmsii* (2) were observed on the following crops:

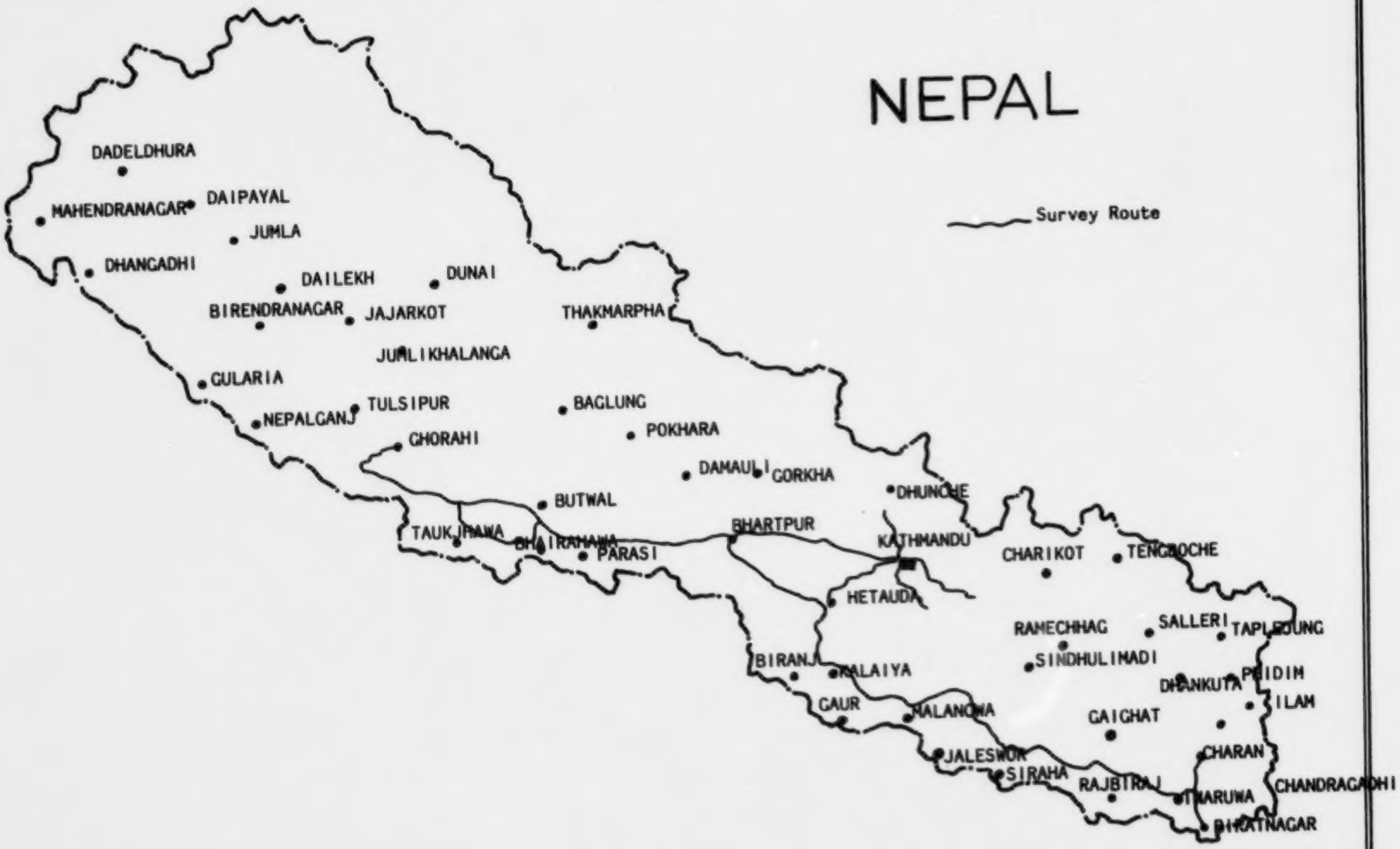
NEPAL
Survey Route
DADELDHURA
MAHENDRANAGAR
DAIPAYAL
JUMLA
DHANGADHI
DAILEKH
DUNAI
BIRENDRANAGAR
JAJARKOT
THAKMARPHA
JUMLIKHALANGA
GULARIA
TULSIPUR
NEPALGANJ
BAGLUNG
POKHARA
GHORAHI
DAMAULI
GORKHA
DHUNCHE
BUTWAL
BHARTPUR
TAUKJHAWA
BHAIRAHAWA
PARASI
KATHMANDU
CHARIKOT
TENGBOCHE
HETAUDA
RAMECHHAG
SALLERI
TAPLEJUNG
SINDHULIMADI
BIRANJ
KALAIYA
DHANKUTA
PHIDIM
ILAM
GAUR
MALANGWA
GAIGHAT
JALESWOR
CHARAN
SIRAHA
RAJBIRAJ
ITHARUWA
CHANDRAGADHI
BIRATNAGAR

Fig. 1. ROUTE OF SURVEY MAP.

Crop	Scientific Name	Orobanche Spp.
1) Toria	B. campestris var. Toria	(1)
2) Sarson	B. campestris var. Sarson	(1)
3) Rai	B. juncea	(1)
4) Broad-leaf mustard	B. juncea	(1)
5) Faba bean	Vicia faba	(1)&(2)
6) Tomato	Lycopersicum esculentum	(1)&(2)
7) Tobacco	Nicotiana tabaccum	(1)&(2)

Besides the above hosts. Orobanche also parasitizes Brinjal (*Solanum melangena*), chillies (*Capsicum* spp.), Turnip (*B. rapa*), Cabbage (*B. oleracea* var. capitata) and cauliflower (*B. oleracea* var. Botrytis).

Some *Orobanche* species have been collected by Royal Botanical Garden at Godavari from different parts of Nepal. Their full description is given in Appendix 2.

Review Of The Past Work On Orobanche

Research work on Brassica oil crops started in 1971. The presence of Orobanche on Brassica oil crops as well as on other crops were realized by the farmers much before that time, but farmers were not and still are not aware of the harmful effect of those beautiful-looking Orobanche plants. Until about 1975, it was not realized as a problem even by the researchers, although it was present in the field. Gradually, the magnitude of the problem increased and for the first time in 1979-80 the author made an attempt to find out the yield loss caused by this parasite.

A superimposed experiment was carried out in a seed multiplication plot of Toria at crop maturity period. Twenty pairs of yield observations were recorded in which each pair consisted of "Orobanche present" and "Orobanche absent" plots. The results indicated that Orobanche was causing an average of about 20% loss in seed yield of Toria.

A second experiment was conducted by the author in 1980-81 in which the main idea was solarization of the soil by covering it with polyethylene sheets. The idea was borrowed from similar research in Israel.

In this experiment, there were a total of nine treatments. In 1-8 treatments the plot's soil was covered by polyethylene sheets for 1-8 weeks, respectively, prior to sowing Toria seed in the plot. The ninth treatment was check i.e., the plot was not covered at all. The results indicated that soil covering by polyethylene sheet for 4-5 weeks significantly reduced the Orobanche population in the plots; however, there was no significant difference in Toria seed yield. Because of its high cost and being impractical for farmers, this experiment could not be continued.

Both of these experiments were conducted at Nawalpur, the headquarters of National Oilseed Development Program (NODP) where Orobanche infestation is very high.

A third experiment was conducted at NODP (1987-1988) in which doses of nitrogen were 0, 30 and 60 kg/ha with constant dose of phosphorus and potash at 40 and 20 kg/ha, respectively. The sub-plots were "Orobanche-not-removed" and "Orobanche-removed" every week.

The results indicated that higher Orobanche population (39-42/m^2) was found in fertilized plots than unfertilized plots (34/m^2). Reduction in Toria seed yield due to Orobanche was found less in fertilized plots (6.6 to 7.6%) than in unfertilized plots (16.3%).

Effect Of Cropping Pattern On Orobanche

In Nepal, Brassica oil crops are grown both in lowland and upland conditions. In lowland conditions, it is grown either after paddy or jute whereas in upland conditions, it generally follows maize. It has been observed that Toria grown after maize has a very high level of Orobanche whereas Toria grown after paddy has a very low level of this parasite. Similarly, Toria grown after jute has a high level of Orobanche. The reason for this effect is not clearly known; however, it is reported that crop rotation with rice and irrigation reduces Orobanche population.

It is also observed that among Brassica oil crops, Toria and sarson (*B. campestris*) have much higher Orobanche infestation than Rai (*B. juncea*). However, the reason is unknown.

Avoidance And Control

Observations and Suggestions

Orobanche has become a serious problem on Brassica oil crops and its population intensity seems to be increasing; however, our awareness of this alarming situation is at very low level. Therefore,

1. Brassica growers should be made aware of the harmful effect of this parasitic weed.
2. Farmers should be encouraged to uproot the parasite and bury it very deep in the ground. Brassica oil crops are generally not weeded, so some incentive to the farmers to uproot Orobanche will be necessary since uprooting and destroying is the best way to control it.
3. Some chemicals like Glyphosate, Methyle bromide, etc. should be tested and their economics studied.
4. Use of trap crop may be very useful, hence should be tried.
5. Study on maize-Toria and paddy-Toria crop rotation should be initiated which can probably provide some useful information about Orobanche germination etc.
6. And, of course, reported resistant or tolerant lines of Brassica oil crops should be obtained and tested in Nepal.

The available tolerant or resistant sources should be exploited.

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APPENDIX - 1

Details of observations made at different locations in the Orobanche (Oro) survey trip

Spot No.	Location	District	Standing crop	Previous crop	No.of Oro/m^2 or per host plant (maximum)	Oro species*	Remark
1.	Rampur Agricultural station,	Chitwan	Toria varietal trial	-	No	-	-
2.	Sharadanagar	Chitwan	Broad-leaf mustard	Toria	2-3/plant in kitchen garden, in the field 5-6/m^2	(1)	Highly variable distribution. Branched and less branched types present. Oro still emerging. Farmer said she does not take any control measures.
3.	Gunjnagar	Chitwan	Toria	Maize	15/m^2	(1)	Variable populations and variable distribution, Oro appears more in upland.
4.	GLIP Research Farm, Rampur	Chitwan	Broad-leaf mustard in kitchen garden		1-2/plant	(1)	Oro was not observed on faba bean, chickpea, lentil, and toria in the field.
5.	Lamkhu, between Rampur & Maranghat	Chitwan	Toria		75/m^2	(1)	Upland conditions. Rainfed crop. Very heavy infestation. Present all over the field. Mature crop has more. Oro still emerging. Oro population highly variable- albinos present, variation for flower color intensity. Farmer not aware of the seriousness of the problem Could be a good field for trial.
	-do-		Broad leaf mustard	(In kitchen garden	81/2.25 m^2	(1)	Severely damaged. Photos taken. BLM with 12 Oro/3m growth reduced, but at 61/2.22m pressure - no yield of leaf at all. Adjacent chilli had no damage.
6.	Mukundapur, Harsha-village, Panchayat, ward No. 7, 14 km from Narayanghat.	Nawal-parasi	Toria	Maize	25/m^2	(1)&(2)	Heavy infestation. Branched and pur unbranched forms present. Less in rice fallows. Present in other fields also.
7.	Pragatinagar, 26 km from Narayanghat	Nawal-parasi	Toria	Maize	26/m^2	(1)	Heavy infestations. Albinos present. Population variable for many characters.

Appendix 1 cont'd.

Spot No.	Location	District	Standing crop	Previous crop	No. of Oro/m^2 or per host plant (maximum)	Oro species*	Remark
8.	Shiv Basti	Nawal-parasi	Toria	-	$85/m^2$	(1)	Very heavy infestations. Crop growth reduced. Upland conditions. Population of Oro variable. Albinos present. Cabbage butter fly (*Pieris brassicae*) was seen visiting Oro flowers, which seem to favour some allogamy. But seed set always full indicating the presence of autogamy.
9.	Bhutaha	Rupandehi	Toria	Rice	No	-	-
10.	Bamahakhola	Rupandehi	Toria	Rice	No	-	-
11.	Musout village Musher Kholal 7km from Lumahi	Dang-Deokhuri	Toria	-	No	-	Crop on a steep hill side. No other crop around.
12.	Jhingani Lakshmipur, Ward No. 2 (Farmer Mohan Bhadur Budhayogi)	Dang-Deokhuri	Toria	Maize	$34/m^2$	(1)	Oro more near bunds. Soils appeared Clayey, Mostly rice fields. Close to a river. Farmer said he does not take any control measures. He has seen it in many other fields. Stem and flower colour deeper purple. Inner tarai area.
13.	Ghorahi, near Traffic Police Station	Dang-Deokhuri	Toria	Maize	$80/m^2$	(1)	Very poor field. Close to town. Just adjacent to a river. Toria Already harvested. Highly variable distribution, six Oro/m to 80/m.
14.	About 5km east of Lumahi	Dang-Deokhuri	Rai	Rice	No	(1)	Mixed with linseed.
15.	Phalkapur	Dang-Deokhuri	Toria+ Lentil+	Maize	$26/m^2$	(1)	No Oro on eggplant and cauliflower, but present on broad leaf mustard in kitchen garden.
16.	Khari, 3km west of Chanranta, Shivpur Panchayat Ward No. 6	Kapil-vastu Dist.	Sarson (yellow) Variety similar to S4	Fallow	$38/m^2$	(1)	Stems mostly yellowish, but flower color like at other places. Children were seen to be playing with Oro. No Oro in adjacent cabbage, raddish and garden pea crops.
17.	Dalpur village near Taulihawa	Kapil-vastu	Toria, Ria, sarson	-	No	-	Farmer's field trial of improved varieties of the Brassica oilcrops. Excellent demonstration. Low lying area. Mostly paddy fields.

Appendix 1 cont'd.

Spot No.	Location	District	Standing crop	Previous crop	No. of Oro/m^2 or per host plant (maximum)	Oro species*	Remark
18.	Barohia, 7km east of Taulihawa to Lumbini	Kapil-vastu	Toria	Paddy nursery	3-4/m^2	(1)	Well drained field. Very close to village. Some capsule eating insects present on Oro.
19.	National Wheat Development Program, Bhairawaha	Rupandehi	Toria, Sarson, Rai	-	No	-	Varietal trials of the three Brassica oilcrops.
20.	Arunkhola	Nawal-parasi	Toria	Rice	No	-	*Pieris brassicae*, cabbage butterfly, abundant. Fields very low lying and and near to a river.
21.	Tandi, near Bharatpur	Chtwan	Toria	-	62/m^2	(1)	Very heavy infestations - all over the fields. Populations variable for branching, flower color and several Oro plants with many roots. Toria poor. But closer to home, Toria is good. Fertilizers effect reducing Oro effects. Possible trial field.
22.	Simal Tandi Farmer - Ram Prasad Pandey	Chitwan	Toria	Paddy	No	-	Late planted crop. Lot of sterility. Very poor seed set.
23.	Jamire village	Chitwan	Toria+ Lentil	Maize	27/m^2	(1)	Toria harvested. Oro drying up. Seeds very well formed. Present in several other fields in the area.
24.	Parwanipur Bazar	-	Raddish, Cabbage, Chillies, Cauliflower, and other garden vegetable crops.	Rice	No	-	-
25.	Parwanipur Agri-Research Station	-	Toria, Rai	Fallow	No	-	Late planted crop. Appears to be generally less in the area because of rice and sugarcane being dominant crops and soil p^H (?) and anaerobic conditions do not favour Oro.
26.	Parwanipur Agri. Research Station	-	Rai	-	No	-	Seed multiplication plot of BR 40 40 Rai variety.

Appendix 1 cont'd.

Spot No.	Location	District	Standing crop	Previous crop	No.of Oro/m^2 or per host plant (maximum)	Oro species#	Remark
27.	Sugarcane Research Station, Jitpur	Bara	Toria, Rai	-	No	-	Very poor soil and very dry. Soil p^H 6-7 (generally). No Oro on tobacco (young crop).
28.	Near Simra, towards Pathaliah	Bara	Toria+ Rai+ Chickpea+ Lentil	-	27/m^2	(1)	Toria just harvested. Oro still emerging. Mostly single stemmed. Population highly variable for flower color. Some Oro with very strong roots.
29.	Nijgadh, near Bakeya river	-	Toria+ Lentil	Maize	Few	(1)	Mostly unbranched.
30.	Nijgadh, Farmer Govind Prasad Acharya	-	Toria	Sugar-cane	57/m^2	(1)	Mostly unbranched, but few branched, Toria harvesting going on. Popultion density highly variable in the field, high intensity across the field.
31.	Chandranigahpur Farmer-Yanga Prasad Dahal	Rautahat	Toria	Rice	62/m^2	(1)	Unusually high Oro levels after rice crop. Probably due to the unsual crop rotation of maize (February-June)-rice (July-October) - Toria (November Janaury). *Pieris brassicae* present. Oro still emerging. Oro with high number of roots - does it lead to multiple parasitism? Both branched and unbranched types present. Very heavy infestation in Toria, but no infestation in buckwheat. Possible trial field.
32.	Santpur	Rautahat	Rai Toria	-	6/m^2 Few present	(1)	Unusually high on Rai. Toria had branched, thick stemmed Oro types.
33.	Begmatti	Sarlahi	Toria+ Chickpea	Maize	48/m^2 (one field, 69/m^2 across the road)	(1)	Toria harvested. Oro dying up. no Oro in adjacent fields of chillies and tomato - might have weeded out. Mostly singly stemmed small plants. Upland conditions. More around farmers' houses. Farmer says that he would plough up after Toria harvest - not aware that Oro seeds are being burried.
34.	Sukha Pokri	Sarlahi	Toria+ Coriander+ Rai	Rice	Very few	(1)	Farmer knew that Oro comes in Toria. Farmers field trial of Rai. Adjacent faba bean crop has no Oro. But farmer has seen Oro on faba bean.

Appendix 1 cont'd.

Spot No.	Location	District	Standing crop	Previous crop	No. of Oro/m^2 or per host plant (maximum)	Oro species*	Remark
35.	National Oilseed Development Program, Newalpur, Sarlahi District: Sarson and Toria equally susceptible. Rai was parasitized, but less compared to Toria and sarson. Oro and host roots connection traced upto one feet away from the host. Surveyed all the Brassica fields to look for an Oro-sick field and found very high levels in many field. Highest Oro density was seen in the Toria varietal trial field and in field No. 10. 21 Oro plants were noticed around one toria plant. In field No. 10, maximum load of 120 Oro/m^2 was observed. All experiments had high infestation levels of Oro. Oro plants were still emerging. Oro has been seen every year since past ten years and is on the increase every year. Field No. 17 and 10, which had the maximum load could be used as trial fields for screening. However, there was significant variability within all the fields. Plot No. 9 had patchy Oro with less on Toria and nil on rai. The rotation being followed at NODP of maize-mustard-groundnut-fallow (2 years), groundnut-mustard (1 year) or fallow-mustard (1 year) may be favouring Oro build up over years. Also the fertilizers being used is possibly promoting high levels of root production which in turn are supporting high Oro levels. Plot No. 9 which had NPLS multiplication had less of Oro. Plot No. 6 had less Oro. This field had relatively less number of mustard crops in the past ten years compared to other fields. In Plot No. 10, which had breeding material, Oro level quite high. All local germplasm lines in this field had Oro indicating that locals are susceptible. Plot No. 12 - Rai had Oro Plot No. 3-Oro was present on toria both in north and south. Chenopodium was a big problem Plot No. 13 PT 30 multiplication - Oro - very high level - not less than 80/m. Albino plants present.						
36.	Bardivas Farmer Sher Bahadur Thapa	Mahottari	Toria	Some fields Rice othres Maize	3-4/m^2	(1)	Mostly rice fields. Some upland Generally Toria area is less. Farmer has seen it in tomato, but more in Toria.
37.	Bardibas	Mahottari	Toria	Rice	No	-	Very poor Toria crop. Low lands.
38.	Chhaharia Farmer Rana Majhiho	Dhanusa	Toria, Fababean, Tomato, Broad leaf Mustard	Maize	2-3/m^2 (on Toria)	(1)&(2)	On Toria, only *O. aegyptiaca* present While on tomato and faba bean, both species were present. Rai, Broad leaf mustard appeared most susceptible.
39.	-	Dhanusa	Tobacco	-	3-4/Tobacco plant	(1)	Present all over the field. Only one species.
40.	Bhulakia	Sirah	Tobacco+ Chickpea+ Sarson	-	3-4/plant present	(1)	3 weeding stage *O. aegyptiaca* on on tobacco are bigger than those on Sarson - due to host nutrition (?) *O. solmsii* does not prefer to attack Sarson (?).
41.	-	Saptari	Linseed+ Rye+ Lentil	Maize	Few	-	Sandy soil.
42.	-	-	Chickpea+ Lentil+ Mustard	Rice field	-	-	-

Appendix 1 cont'd.

Spot No.	Location	District	Standing crop	Previous crop	No.of Oro/m^2 or per host plant (maximum)	Oro species*	Remark
43.	Bisampur	Saptari	Mustard+ Lentil	Upland Rice	-	-	Sandy soil.
44.	Bhawanipur	Saptari	Mustard+ Lentil	Rice	-	-	No Oro on radish and potato.
45.	Before Bhardah	Saptari	Wheat+ Sarson	Rice	-	-	-
46.	After Koshi	-	Wheat+ Mustard, Cabbage, Sweat potato	Rice	-	-	-
47.	Inaruwa	Sunsari	Mustard+ Chickpea	Pusha Rice	5/m^2	(1)	Near farmer's houses. Well aerated land.
48.	1km from Itahari to Dharan	Sunsari	Lentil+ Mustard	Rice	-	No	-
49.	Kanchanbari Ward No. 4	Morang	Lentil+ Mustard	Jute	23/m^2	(1)	After effects of Jute appears to be similar to that of maize.
50.	Duhabi	Sunsari	Lentil+ Mustard	Rice	-	-	-
51.	Duhabi	Sunsari	Lentil+ Linseed	Rice	-	No	-
52.	Pakali	Sunsari	Lentil+ Mustard	Jute	65/m^2	(1)	Jute-mustard rotation followed every year.
53.	Tarahara Agric. Station	Tarahara	Varietal Trials	Rai & Toria	-	No	-
54.	Musarnia	Sunsari	Tobacco	-	26/tobacco plant	(1)	Variability within the field for growth of tobacco and distribution of Oro.
55.	Prayagpur	Siraha	Tobacco	-	10/tobacco plant	(3)&(1)	More of *O. aegyptiaca* as compared to *O. solmsii*
56.	Daman	-	Mustard	Maize	-	No	-
57.	Swayambhu area	Kathmandu	Mustard	Maize	-	No	-
58.	Koteswar	Kathmandu	Mustard	Maize	-	No	-

Appendix 1 cont'd.

Spot No.	Location	District	Standing crop	Previous crop	No.of Oro/m^2 or per host plant (maximum)	Oro species*	Remark
59.	-	Bhaktapur	Potato+ Broadbean	-	-	No	-
60.	Way to Banepa	Bhaktapur	Mustard+ Faba bean	-	-	No	-
61.	Mchatgaon	Bhaktapur	Mustard	-	-	No	-
62.	Dhulikhel	Kavre	Mustard	Maize	-	No	-
63.	Dhulikhel	Kavre	-	-	-	-	-
64.	Temaghat	Kavre	Mustard	Maize & Rice	-	No	-
65.	Panchakhal	Kavre	Wheat+ Mustard	Maize	-	No	-
66.	Muskhugaon	-	Mustard	-	-	No	-
67.	Tinpipale	-	Mustard	Maize	-	No	-
68.	Way to Ranpouwa	-	Mustard	Maize	-	No	-
69.	Ranipouwa	-	Mustard	Maize	-	No.	-
70.	Tupche	Nuwakot	Mustard	Rice	-	No.	-
71.	Bodewari & Khumal	Lalitpur	Mustard	Maize	-	No.	-

APPENDIX -2

Detailed observation available on Orobanche specimens in the herbarium at Royal Botanical Garden, Godavari, Lalitpur, Nepal.

Specimen 1:

O. aegyptiaca pers. No., 7/1967
collected by: D. Nicolson
Date of collection: 2 December 1966
Location of collection: Seti Zone, Kailali Dist., Road between Bajani and Seti, 30 miles east of Dhangarhi.

Altitude: 150m
Observations: Flowers white to blue, frequent in mustard fields: Flowers bracteolate, D.H. Nicolson 2817.

Specimen 2:

O. aegyptiaca Pers. No. 74/2355
Collected by: D.P. Joshi and T.K. Bhattacharya
Date of collection: 9 August 1974
Location: At Khungsong (Manang)
Altitude: 3800 m
Observations: On open places, root parasite, flower pinish

Specimen 3:

O.aegyptiaca No. 7644
Collected by: Chandra Bali

Common name: Guriya
Locality: Ganeshpur, Nepalgunj
Observations: Small weed in mustard field, flowers violet
Date of collection: 18 December 1972.

Specimen 4: Same as 3.

Specimen 5:

O. aegyptiaca Pers. No. 74/2355
Date of collection: 18 February 1971
Location: Barkhurwa (Dhanukha)
Altitude: 150 m
Collected by : N.P. Manandhar
Remarks: Growing on tobacco in cultivated fields. Flowers blue.

Specimen 6:

O. aegyptiaca No. 17053
Date of collection: 18 February 1971
Collected by: N.P. Manandhar
Location: Barkhurwa, Dhanukha
Altitude: 150 m
Remarks: Growing on tobacco in cultivated fields - Flowers blue.

Specimen 7: Same as 6.

Specimen 8:

O. aegyptiaca Bois. No. 17929
Common Name: Sacco Bet
Location: Tarahara
Altitude: 230m
Collected by: A.P. Singh and M.B. Rana Chettry
Remarks: Growing in mustard fields, parasitic herb-flowers blue
Date of collection: 23 January 1974

Specimen 9: Same as 8.

Specimen 10:

O. aegyptiaca pers. No. 75/2881
Location: Tarahara
Altitude: 150m
Collected by: T.K. Bhattacharya and M.B. Chettry
Remarks: Root parasite on Brassica nigra (Black mustard)-flowers blue, very common in tori fields.

Specimen 11:

O. caerulescence Stapf. No. 17783
Date of collection: 29 August 1927
Location: Tarahara village
Altitude: 250m
Common name: Nilo phool
Remarks: Root parasite, flowers bluish white

Specimen 12:

O. caerulesence Stapf. ex. Willd No. 1998
Location: Rawchuli, Jila Valley, W. Nepal
Altitude: 7000 ft.
Date of collection: 2 May 1952
Collected by: O.Polunin, W.R. Sykes and L.H.J. Williams
Remarks: Corolla deep purplish blue. Stamsen and Style White - Growing in waste places on dry exposed ground. Growing nearby were various graminae and Artinisae (No. 1997)

Specimen 13:

O. caerulescence Stapf. ex. willd. No. 9179
Location: Bhurabari, Surkhet
Altitude: 390 m
Collected by: S.P. Adhikari, N.P. Manandhar
Date of collection: 7 December 1982
Remarks: Herb in mustard field - flowers violet

Specimen 14:

O. caerulescence stapf. No. 8285
Location: Nayasdar - Topn, Bajhang Dist.
Altitude: 3000 m
Collected by: P.R. Sakya, M.K. Adhikari and M.N. Subedi
Date of collection: 28 July 1984
Remarks: on the floowr in oak-conifer forest - flowers dull purple

Specimen 15:

O. caerulescence stapf. No. 4316
Location: Godavari
Altitude: 5500 ft
Remarks: Herb in open and dry places. Rare. Violet
Collected by : P. Pradhan.

OIL CROPS IN BHUTAN

Tayan Raj Gurung

Bhutan occupies a land area of 46,500 sq. kms and lies between latitudes 26^{0} 45′ N and 28^{0} 10′ N and between longitudes 88^{0} 45′ E and 92^{0} 10′ E (Fig.1.). The population is just above 1.3 million (1986) with a population density of 28.2 persons per sq. km. The country can be divided into three distinct geographical zones corresponding broadly to three climatic zones. The southern belt (250m-1500m elevation) has a hot humid climate with temperatures remaining fairly even thrbughout the year between 15^{0}C and 30^{0}C with a rainfall ranging between 2500 mm to 5000 mm; the central zone (1500m-3000m) has a cool temperate climate with a rainfall averaging about 1000 mm; the northern region (above 3000m) has a severe alpine climate with annual rainfall around 400 mm. There is a dramatic variation within these broad ranges and the climate and rainfall characteristics change dramatically from one valley to the adjacent one with consequent sharp changes in the agricultural production.

The economy of Bhutan is primarily based on agriculture with arable land less than 9% of the total area and 90% of the population is dependent on agriculture with average land holding of 1.6 ha. Cereals are the high priority crop but oilseed crops and pulses are gradually gaining their importance. The major oilseed crops grown in Bhutan are mustard/rapeseed, groundnut and nigerseed. Mustard is the predominant oilseed crop. The domestic oilseed production, which is largely for subsistence purposes has risen from 1900 tons (1981) to an estimated 3700 tons (1986). Assuming 33% oil extraction rate and 15% yield increase per year the production for 1986 would be 12,220 tons of edible oil which accounts for only 30% of the domestic requirement. This indicates that bulk of the edible oil requirement has to be met by imports. Table 1 shows the increasing trend in acreage and production of mustard in Bhutan.

Table 1. Total area and production of mustard in Bhutan

Year	Area ('000ha.)	Production ('000MT)
1981	2.9	1.9
1987	5.0	3.5
1987	5.5	3.9

The import of major edible oil is made by (Food Corporation of Bhutan) FCB and to a lesser extent by private sectors. The import of edible oils in 1984 was 1288 MT which went upto 2175 in 1986 (Table 2). During 1986, out of 2175 tons of edible oil imported, about 36% was rapeseed oil, 20% palm oil and 26.4% other vegetable oil (Table 3.)

Table 2. Import of edible oils in differnet years (MT)

Year	WFP imports	Total amount important
1984	534.2	1288.0
1985	101.4	1600.5
1986	327.2	2175.0

Table 3. Import of edible oils during 1986

Commodity	Quantity imported (MT)	Share (%)
Rapessed oil	782.7	35.9
Palm oil	441.9	20.3
Other Veg. oil	575.1	26.4
Groundnut oil	27.9	1.3
Mustard oil	20.0	0.9
WFP imports	327.0	15.0

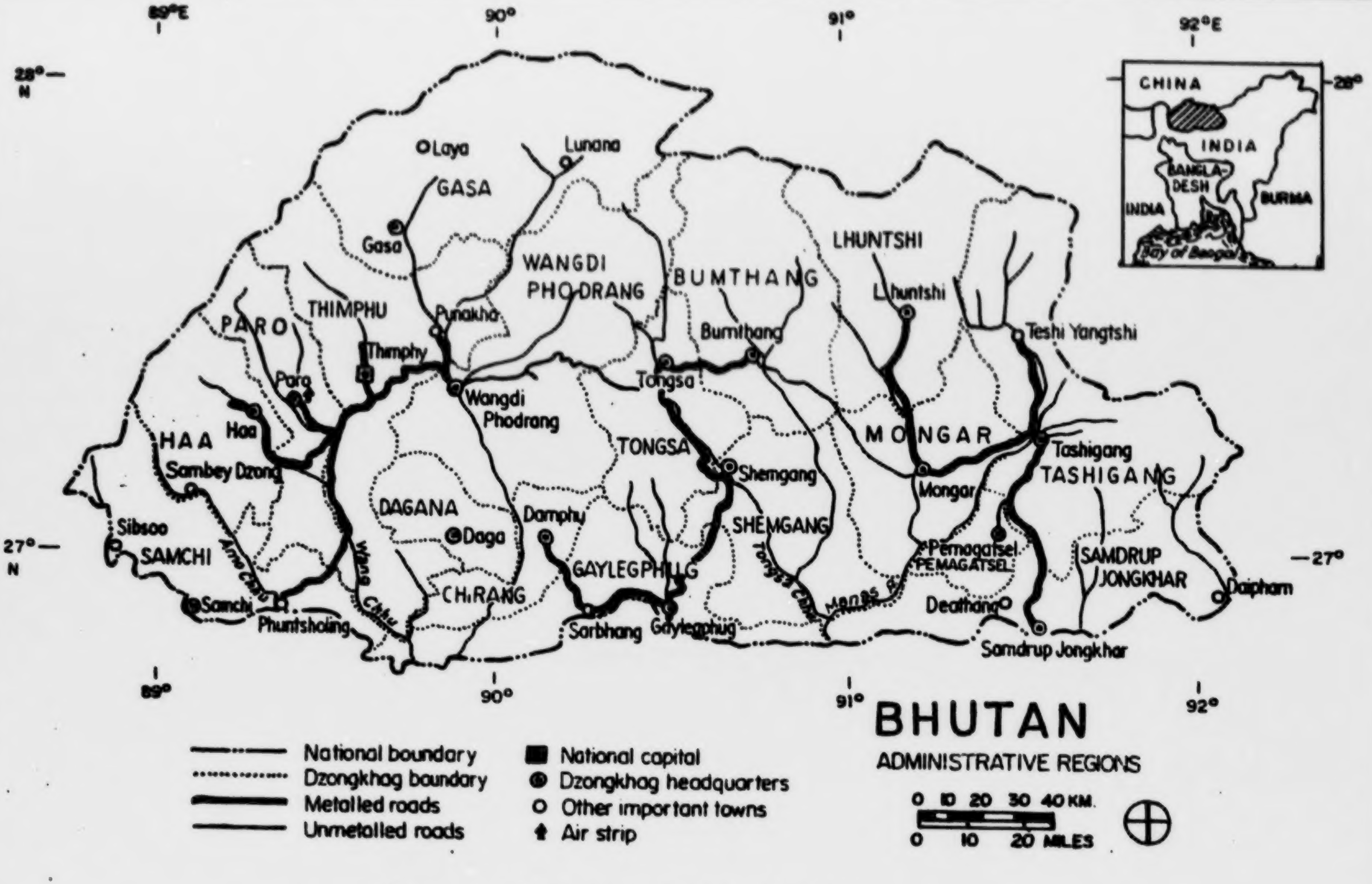
89°E
90°
91°
92°E
28° N
27° N
28°
27°
89°
90°
91°
92°
CHINA
INDIA
BANGLA-DESH
INDIA
BURMA
Bay of Bengal
Laya
Lunana
GASA
Gasa
WANGDI PHODRANG
BUMTHANG
LHUNTSHI
Lhuntshi
Teshi Yangtshi
PARO
THIMPHU
Punakha
Thimphy
Bumthang
Tongsa
Paro
Wangdi Phodrang
Haa
HAA
MONGAR
Tashigang
TONGSA
Shemgang
TASHIGANG
Sambey Dzong
Mongar
DAGANA
Damphu
Sibsoo
Daga
SHEMGANG
Pemagatsel
SAMCHI
Amo Chhu
Wang Chhu
GAYLEGPHUG
Tongsa Chhu
PEMAGATSEL
SAMDRUP JONGKHAR
Manas R.
CHIRANG
Deathang
Daipham
Samchi
Phuntsholing
Sarbhang
Gaylegphug
Samdrup Jongkhar
BHUTAN
ADMINISTRATIVE REGIONS
National boundary
Dzongkhag boundary
Metalled roads
Unmetalled roads
National capital
Dzongkhag headquarters
Other important towns
Air strip
0 10 20 30 40 KM.
0 10 20 MILES

Figure 1. Administrative districts of Bhutan.

(Source: RGOB Fifth Plant Document, 1981-87).

Oil Crops in Bhutan

Mustard

Mustard is the predominant oilseed crop in Bhutan. It is grown from 200m to 3000m elevation. The principal species grown is *Brassica campestris* type Toria. Most of the mustard is grown in unterraced and rainfed areas with roughly 10% of the mustard produced on paddy lands after rice. At high altitude area (above 3500m) two different mustards are grown; a biennial type planted in June in mixture with buckwheat and harvested next May, and an annual type grown from April to September. In mid and low altitude areas, mustard is grown in October-November and harvested in February-March followed by maize/rice. The highland mustards cultivated under dryland conditions yield about 420-1000 kg/ha and have high altitude adaptation to cool conditions. However, the national reported seed yield of mustard accounts for 700 kg/ha which is fairly good. The area, production and average yield of mustard in different Dzongkhags (Districts) given in Table 4 and Fig 1, indicate that the major mustard areas are concentrated in low and mid altitude areas. The characteristics of Local mustards are:

- mature in 110-130 days
- short statured
- Low to moderate resistance to pest and diseases
- low yielding ability
- 33% oil recovery
- sensitivity to water logging
- wide adaptability.

Groundnut

Groundnut, an important oilseed crop, is gradually gaining its importance in Bhutan. The major area under groundnut is concentrated in eastern region. It occupies about 0.5% of the net oil crop area. Groundnut is grown in small-scale and its potential, as an important oilseed crop, has not been tapped. The total groundnut produced is consumed as roasted kernels and the only reason being the lack of oil expeller for groundnut. In Bhutan two local types (Jangphu and Uzorong), which are spreading types are widely grown. The cultivation methods practiced in the region are: ridge and furrow method and flat bed method. The characteristics of local groundnut are:

Table 4. Acreage, production and productivity of mustard in different Dzongkhags (1984)

Dzongkhag	Area (ac)	Productivity (kg/ac)	Production (MT)
Bumthang	218	220	49
Chirang	1524	340	512
Dagana	1046	320	357
Gaylegphug	2056	300	618
Haa	111	270	30
Luntshi	545	210	115
Mongar	479	220	105
Paro	433	260	113
Pemagatshel	54	240	13
Punakha	473	290	139
Semgang	556	310	174
Samchi	1116	210	235
Samdrup-Jongkhar	1591	310	487
Thimphu	443	280	124
Tashigang	1042	230	224
Tongsa	255	260	66
Wangdiphodrang	377	260	97
Total	12318	266.5	3458

Source: Policy and Planning Division, Dept. of Agriculture.

- late maturing (165 days)
- low yielding ability (800 kg/ha.)
- moderate resistance to Tikka disease
- spreading type.

Considering the topography of

Bhutan, spreading types are preferred as they have the ability to minimize soil erosion. Taking this in to consideration, we have started popularizing the local varieties which have the above cited property through farmers' field trials. Farmers are showing their interest in groundnut cultivation as they have understood the importance of groundnut as an oil crop.

Nigerseed

Nigerseed *(Guizotia abyssinica)* is presently grown in small areas in Bhutan. The crop is generally sown in drylands after the harvest of maize in August. The total produce is used for pickling and not for oil extraction because of the very low yield.

Sunflower

Sunflower is widely grown in Bhutan as an ornamental plant. Its importance as a high value oil crop is not understood by the farmer. Once they are aware of its importance and the necessary inputs and processing facilities are made available, they will take up the crop in large-scale. In some initial tests, higher yields of sunflower have been reported in high altitudes when planted in spring.

Oils from Forest Trees

The practice of extracting edible oils from forest trees began in early days. There are few trees the fruits of which are used for oil extraction. For instance, "Singma" a tree that spontaneously grows in land used for shifting cultivation. Other native oil bearing trees are known as "Ponsi" and "Mafua". The information on cultivation methods, oil extraction and uses of oils from these trees are not available.

Constraints In Increasing The Production Of Oilseed

1. Oilseed crops are grown in rainfed areas with soils of poor fertility.
2. Farmers are small and marginal, (Average land holding:1.6 ha).
3. Farmers are not in a position to invest adequate inputs.
4. Farmers use traditional and less productive methods of technologies.
5. Lack of improved production technologies for specific areas.
6. Lack of high yielding varieties suitable for different agro-climatic zones.
7. Lack of varieties resistant to pest and diseases. (Mustard : Aphids, Sawfly, white rust Groundnut : Hairy caterpillar, Leaf spots, Rust).
8. Production and distribution of quality seeds.
9. Lack of proper and efficient oil expellers.
10. Lack of assured market and marketing facilities.

Processing And Marketing

Most of the mustard oil produced in Bhutan is processed on the farm for home consumption using traditional methods. The traditional methods are only half as efficient as the mechanized methods. In cash terms, the farmer currently pays Nu./Rs.1.80 for milling 1 kg mustard which produces 0.374 litre of oil worth Nu./Rs.13.46 (Assuming Nu.33 per litre of mustard oil).

As most of the mustard producers consume their own produce, except for the portion rendered to the expeller, there is little or no marketing of mustard seed or oil at the moment. Producers take back the oil cake for their cattle.

Some amount of mustard oil is marketed by the expellers who sell it at about Nu.33 per litre. The edible oil market is supplied mainly by FCB. The low priced FCB oil tends to discourage local production, processing and marketing of oil.

Oilseed Research And Development

Very little has been done so far on the improvement of oilseeds in Bhutan. Systematic and carefully formulated research program is yet to begin. However, as a first step to oilseed research, few varietal trials of different oil crops were conducted at different regions by the Department of Agriculture DOA.

Oilseeds research and development coordinated from Center for Agricultural Research and Development (CARD) is being initiated with the objectives of increasing oilseed production under the three environments of the country indicated below:

1. The present rice-fallow areas.
2. The maize-mustard areas or drylands.
3. The high altitude areas. (winter type mustard have good potential).

Mustard

A preliminary study was conducted at CARD in 1987 to examine the performance of few improved mustard varieties (T9, Varuna, Yellow Sarson and Bajo local). The result, in Table 5 indicates that fairly good yields of T9 can be obtained even with November seeding in medium altitudes. The yield of Varuna was slightly higher but late in maturity.

Cropping pattern trial

It was demonstrated by CARD, Wangdiphodrang that a mungbean seed can be fitted into the mustard-rice cropping pattern. If mustard is sown early, it can be harvested in late February or early March which gives time for the 75-100 days mungbean crop to mature before rice. In 1986-87 a preliminary trial to examine the benefits of modifying local mustard production practice and to look at the effects of introducing mungbean into the mustard-rice rotation was conducted.

The result in Table 6 indicates that the total annual production of mustard-mungbean-rice pattern was 42% higher than that of the mustard-fallow-rice. There was a sizeable increase in mustard seed yield as a result of increased fertilizer use. The improved mustard variety T9, though rather late maturing than local mustard, has higher yield potential and should give greater returns to investment. Variety T9 may be more suitable for improved mustard-rice cropping pattern.

Table 5. Comparison of local and improved mustard varieties

Sowing date : 15.11.86
Fertilizer : 35:20:0 NPK kg/ha. + FYM 6t/ha.
Irrigation : 3 times (CARD 1986-87)

Variety	FLW days	Harvest days	Mean yield (t/ha)*
Bajo local	45	119	0.755
Type 9 a	77	139	0.783
Type 9 b	77	139	1.217
Yellow Sarson	77	139	0.500
Varuna	85	150	1.368
Rape Cv. Rally c	126	-	-

a) Original stock CV% = 14.3
b) Seed increased by CARD 1985 LSD = 0.264 t/ha
c) Late flowering - not harvested
* 7% MC or below.

On-going research on mustard (1988-89)

I. Preliminary observation nursery

Objectives: Evaluation and identification of best lines/ varieties for post rice, post maize and high altitudes.

Table 6. Experimental cropping pattern performance, winter and summer crops 1986-87, CARD.

	Winter crops 1986-87			Summer crop 1987			Total annual
Cropping pattern	Variety	Fertilizer rate*	Mean yield t/ha**	Variety	Fertilizer rate*	Mean yield t/ha**	yield t/ha)
a. Experimental	Mustard Bajo local	35:20:20 FYM 7t	0.705	Rice K39-96-1--1-1-2	None	5.100	6.360
	Mungbean PAG ASA 1	0:30:00	0.555				
b. Farmer Practice	Mustard Bajo local	None	0.556	Rice Zakha local	None	3.900	4.456

* NPK in kg/ha, FYM in t/ha; ** Rice 14% MC, Mustard 8% MC.

It is basically a varietal screening nursery. The nursery comprises 21 introduced lines (Sources: Bangladesh, Ethiopia, India, Nepal, Pakistan, Sri Lanka) and 37 local types collected from different parts of the country. A standard check variety T9 along with a local check is included after every 10 entries.

The trial is conducted in four locations:

1. CARD Wangdiphodrang: Post rice (Altitude : 1200m)
2. CARD Sub-station Bhur : Post Maize (Altitude : 250m)
3. CHIP (Chirang Hill Irrigation Project), Chirang : Post maize (Altitude : 1500m)
4. BNPP (Bhutan National Potato Program) : High altitude (Altitude : 3000m).

II. Time of sowing (sequential sowing)

Objectives: to determine the optimum time of planting for a given environment and also to evaluate the performance of some popular mustard varieties.

The trial is laid out in split plot design with two replications, planted from September to December with T9, M27, Varuna, Yellow sarson and local. The trial is conducted in five locations:

1. CARD, Wangdiphodrang
2. CARD, Sub-station Bhur
3. CHIP, Chirang
4. BNPP, Bumthang
5. IFAD, II Tashigang-Mongar (Altitude: 1200m)

III. SAARC MLT on rapeseed-mustard

Objective: to identify the suitability of rapeseed-mustard varieties in member countries for their commercial exploitation.

The trial is conducted at CARD-Wangdi comprising 32 rapeseed-mustard varieties from SAARC member countries.

IV. Mustard fertilizer trial (CARD/FAO Fertilizer Project)

Objective : to find out the economic NPK dose for mustard in rice and maize based cropping systems.

This trial is being conducted in farmers' fields throughout the country. The trial comprises 10 treatments.

V. Cropping Pattern Trial

Objective: to compare existing farmers' cropping pattern with the improved patterns viz., mustard-mungbean-rice; mustard-sesbaniarice.

Groundnut

A systematic research on groundnut is yet to be initiated. Research in groundnut started only last year with SAARC MLTR, where 19 varieties were tested in unreplicated observation plots. From the trial, three Indian varieties (M-13, Chandra and Kadiri 3) have been selected as the best performers. As the trial was actually meant for seed multiplication for the first year, this year we have a replicated trial of the same materials at CARD. Rust incidence at a later stage of the crop seems to be the biggest problem. Tikka disease to a lesser extent was also observed in all varieties. Another varietal trial of 17 ICGV lines was conducted at Chirang. At Chirang, Tikka seems to be the major problem.

In general, groundnut takes longer time to mature and as a result it occupies the field for major part of the year. Any variety selected should be early maturing and cold tolerant so that it can be fitted in the existing cropping system without replacing the major crops.

Sunflower

In Bhutan sunflower is widely grown as an ornamental crop which indicates that it can grow well in that area. It was first introduced as an oil crop in 1974. A preliminary observation/variety trial was conducted by BNPP, Bumthang from 1978-82. The result of the introduction trial with different sunflower cultivars is summarized in Table 7. Between 1974-1984, 19 cultivars were introduced and tested. Yields in replicated experiments ranged form 0.57 to 3.1 MT/ha. Oil content of some cultivars tested at Bumthang were reported to be 37-52%
With yields upto 3 MT/ha. and 37-52% oil content, it appears to be the best oil crop in Bumthang. Attempts to bring this new oil crop to the farmers have not been very successful so far mainly due to the following reasons:

a) insufficient support, mainly seed supply
b) lack of oil expellers.
c) lack of improved production technologies.

Conclusion

Systematic agricultural research in Bhutan started only in the early eighties. The research at present is under constant review and modification. The oil crop research is just starting. The present experience indicates that there is potential for increasing the oilseed production per unit area provided appropriate technology, inputs in the form of good quality seeds of improved/local varieties, fertilizers, plant protection measures and related technical knowhow reach to farmers. Our oil crop research and development program which has been initiated with great hope works towards generating economic package of practices thereby increasing the oilseed production and fulfilling the government's goal of self-sufficiency in edible oils.

Any technology generated by research should fit in the existing cropping system and in no way disturb the cereals which are the staple crop. For this, it is important to understand the cultural and agro-ecological conditions of the farming systems. The oil crop variety which is early maturing, high yielding, pest and disease resistant, frost resistant and adapted to high altitudes is the type we would promote in Bhutan. The exotic groundnut materials received through SAARC MLT and mustard, ICRISAT, and Oil Crops Network are being tested

Table 7. Sunflower Introduction Trials (Yield t/ha.) BNPP, Bumthang

Cultivars	1978	1979	1980	1981	1982
CH	0.67	1.68	2.24	3.02	1.50
Issanka	0.66	1.57	0.57	1.69	1.50
Mikopolski	0.89	1.66	1.52	2.15	-
East Europe	-	-	1.63	1.96	1.85
Kenya White	-	-	-	3.10	2.18
Sun-Hi 5104	-	-	1.76	1.73	1.73
IH 84	-	-	-	-	1.69
IH 56	-	-	-	-	2.43
IH 55	-	-	-	-	2.00
IH 81	-	-	-	-	1.92
IH 51	-	-	-	-	1.90
Airelle	-	-	-	-	2.20
Primasol	-	-	-	-	1.86
Luciole	-	-	-	-	1.40
Elia	-	-	-	-	1.94
Rodeo	-	-	-	-	2.15
Olga	-	-	-	-	1.57
Sorex	-	-	-	-	1.89
Vera	-	-	-	-	1.80
Seeding date:	24.4	19.4	7.4	17.4	15.4
Harvest date:	-0.10	7.9	-	5.10	8.10
NPK kg/ha	22:43:0	-	121:125:0	112:112:0	75:75:0

under different environments and we hope to get promising varieties from the lot.

As stated earlier, we have shortage in edible oil as the domestic oil production accounts only for 30% of the national requirement. To compensate this shortage, greater emphasis must be given to mustard, groundnut and sunflower as oil crops because of their adaptability to diverse environments in Bhutan. On the other hand, processing would be a limiting factor. Therefore, production and processing must develop simultaneously. At the same time we will explore the possibilities of other oil crops like linseed and sesame in Bhutan for which we have already identified seed sources for introductions.

With the assistance from the Oil Crops Network, we hope to develop our oil crop research and production in the near future.

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BRASSICA PRODUCTION AND RESEARCH IN PAKISTAN[1]

Rehmat Ullah Khan and Masood A. Rana

Rapeseed-mustard are important oilseed crops in Pakistan. They contribute about 22% of the domestic production of edible oil. Presently, 347,000 tones of edible oil is produced in the country which meets about 30% of the total consumption. The deficit of edible oil is met through imports at a heavy cost of foreign exchange. Its import bill was Rs. 6128 million, i.e., US $408 million during 1986-87.

Area, production and yield

It is evident from Table 1 that the area under Brassica has been gradually declining and the production is almost static. There has been some increase in seed yield per hectare over the same period but it is still very low as compared to other rapeseed-mustard growing countries of the world, Table 2.

Distribution or area

Province-wise area and production of rapeseed-mustard crops is given in Table 1. Approximately 25% of the *Brassica* crop is sown in Barani (rainfed) areas and the remaining is planted on irrigated lands. Among the four provinces, Punjab has the largest share of 53% in the total area, whereas Sind, NWFP and Baluchistan contribute 25, 15 and 7% respectively.

Rapeseed-mustard crops

Four Brassica species, *i.e, B. campestris, B. napus B. juncea* and *B. carinata,* are grown in the country. These are grown in two seasons, i.e., Zaid Kharif (Autumn season) and Rabi (winter season). Total area under rapeseed-mustard in the country is almost equally distributed among Zaid kharif and abi seasons. The nomenclature of the varieties which are grown in Pakistan is shown in Table 3. Oilseed rape (*B. napus*) has recently been introduced in the country and it is grown mainly in the cooler northern (NWFP) and central regions of Pakistan. *B. carinata* has gained popularity only recently and the first cultivar in this species, "Peela Raya", is being seen as a potential crop in Punjab with high seed yield, having disease and drought tolerant characteristics.

Table 1. Province-wise area and production of rapeseed-mustard in Pakistan

	Area ('000 ha)					Production ('000 tone)					
Years	Punjab	Sind	NWFP	Balu*	Total	Punjab	Sind	NWFP	Balu.	Total	Ave.**
1980-81	244.7	104.9	41.6	25.8	417.0	157.3	63.8	21.1	10.3	252.5	606
1981-82	223.6	102.0	46.9	18.4	390.0	145.7	61.2	22.5	9.4	238.8	611
1982-83	221.3	100.6	44.2	19.4	385.5	153.7	60.4	21.2	10.7	246.0	638
1983-84	150.6	96.1	43.0	23.0	313.3	127.8	57.6	18.2	13.4	217.0	693
1984-85	185.6	86.2	50.9	24.2	346.9	149.3	49.7	21.9	13.9	234.8	711
1985-86	206.8	83.1	36.4	24.3	350.6	171.7	48.0	16.1	14.1	249.4	750
1986-87	-	-	-	-	361.6	-	-	-	-	270.7	749

*Balu.: Baluchistan. **Ave.: Average yield (kg/ha).

Source: Agricultural Statistics of Pakistan, 1986.

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[1] Received but not presented.

Table 2. Comparison of average yields of rapeseed-mustard

Country	Yield (kg/ha)
India	688
Pakistan	725
Canada	1235
China	1243
Japan	1952
Poland	2296
France	2991
France	2991

Source: FAO Production year book, vol. 39, 1985.

Table 3. Nomenclature of rapeseed-mustard (Brassica spp.) and their growing season in Pakistan

Botanical name	Eysh. name	Local name	Sowing season
B. campestris	Toria	Toria	Zaid Kharif: Aug to 10th Sept.
B. juncea	Brown mustard	Porbi Raya	- do -
B. juncea	Brown mustard	Raya	Rabi: October to 10th Nov.
B. campestris	Yellow sarson	Peeli sarson	Rabi: October to 15th Nov.
B. campestris	Brown sarson	Bhuri sarson	- do -
B. napus	Winter rape	Ghobi sarson	- do -
B. carinata	Abe Sina raya	Ghobi sarson	- do -

Current brassica research status

There are seven research stations currently working on *Brassica* crops. The major breeding programs are located at Tanodjam, Faisalabad, and Islamabad. About twenty scientists in five deciplines are working on all of rapeseed-mustard crops. The majority of breeding efforts is placed on *B. juncea* and *B. carinata*. Only National Agricultural Research Centre at Islamabad has a major breeding program on *B. napus* while there is no centre working on breeding of *B. campestris*. The program at Islamabad is conducted under the sponsorship of the BARD project, and the Canadian CIDA Project. The breeding program was initiated three years ago and was staffed by one breeder who left the project in February, 1988 to join Agricultural College. One M.Sc. level breeder will shortly proceed to Canada for Ph.D. In this way only one research agronomist and one extension agronomist will be left to look after the whole Brassica program at NARC. The BARD Project has the following role.

Role of BARD project

1. Conducting National Uniform Rapeseed-mustard yield Trials.
2. Organize travelling seminar.
3. Conduct breeding and genetic studies to develop the "double-low" strains in *B. napus*.
4. Conduct agronomy studies to increase yields.
5. Promote out reach activities.
6. Increase seed of canola cultivars.
7. Providing training facilities.

Activities and achievements

1. Established optimum plant population and planting time for *B. napus and B. campestris*.
2. Studied the various insecticides to control biting and sucking insects.
3. Studied herbicide for grassy and broad-leaf weed control.
4. Determined fertilizer application methods and rates.
5. Developed seeding equipment.
6. Prepared production recommendations.

Rapeseed maximization

1. Introduced improved production technology to the farmers.
2. Demonstrated seeding, harvesting and threshing equipment.
3. Produced canola oil from local crushing equipments on large-scale.
4. Refined and packed canola oil for introducing it to the consumer.

Future thrusts

1. Involve local seed certification and production agencies for producing canola seed.
2. Stimulate the promotion of crushing and processing of canola.
3. Complete technology package.
4. Develop *B. napus* canola type varieties for Pakistan.
5. Increase acreage under canola.

We endorse the last year's presentation of M. Munir and G. R. Stringhum regarding the "current needs involving international cooperations" as follows:

- germplasm exchange among scientists in each country;

- international strain trial of basic cultivars to be conducted initially at National Research Headquarters of each country, could be coordinated by IDRC;

- collaborative research programs on disease and insect resistance, particularly Alternaria, Sclerotinia and aphids;

- public relations comaign to inform governments of international programs underway and to solicit approval for workshop and conference travel;

- inclusion of Pakistani Scientists on Brassica Network newsletters and other reports;

- establishment of a central file of Brassica research papers with access through photocopy service.

SUMMARY AND WRAP-UP FOR BRASSICA SUB-NETWORK MEETING

Hugh Doggett

Dr. S.C. Modgal, Director of Research, noted in his speech of welcome that the G.B. Pant University had recently released four new Brassica varieties, and several more had been identified for release. India had made proud progress in cereals, but progress in Brassica is lagging: over the previous 10 years, production had increased by one million tons, some 10%. Imports of edible oils still require 12,000 mill. rupees each year. Much of the production increase from irrigated areas had come from cereals. Brassicas occupy large dryland areas, which need to contribute more to increased production. Better varieties and better cropping systems are required, including increased use of intercropping.

The Vice-Chancellor, Dr. Mahatim Singh, then opened the meeting. He welcomed delegates to the University, and to the State of Uttar Pradesh. India faced with a huge shortage of edible oil, had launched a "Technology Mission on Oilseeds". A special thrust for improved production and productivity of rapeseed-mustard in U.P. is being made. U.P. is the State with the greatest production of these oilseeds. The productivity of Brassicas in U.P. increased from 573 kg/ha in 1982-83 to 707 in 1986-87. The planned productivity for 1989-90 is 890 kg/ha.

Dr. Nicolas Mateo thanked the Vice-Chancellor and Dr. Modgal. He emphasized that IDRC is committed to research and development on oil crops, so sharing a common goal with the group. He hoped that the Workshop would provide the opportunity to reflect on the priorities, focus on the changing needs, and the whole role of the Network.

Dr. Mangala Rai, ADG (Seeds) ICAR, noted that cereals production had increased since 1949 from 6.34 to 45.6 million tons, +690%. Corresponding figures for oilseeds showed an increase of only +140%. The prices pattern had been unusual: oilseed prices had risen even though production had risen. Low prices at harvest doubled within two months. Technology is rapidly improving. Even though 85% of the oilseeds are rainfed, their production reached its second highest level in 1987, the year in which the drought was the worst of the century. Soya has spread everywhere, toria, sunflower, and sesame are increasing in area day by day. Seed production for oilseeds (including groundnuts) has doubled: the amount of breeders' seed produced this year is expected to treble. Dr. Mangala Rai then made a major point: if only all the oil could be extracted from the oilseeds produced, the increase would cover the whole of India's edible oil deficit. Two issues arose from this introduction: (i) costs of growing the rainfed crop must be minimal; improving resistances to pests and diseases is one obvious approach to achieve this. (ii) The government support-price at harvest should be high enough to offer a good return to the grower, thus removing the temptation to sell to anyone with ready cash.

Dr. Abbas Omran then outlined the development of the Network, noting that it now includes China and the "South East Asian Region".

The Brassica Sub-Network

Dr. Hiruy Belayneh then reported on the progress made in implementing the excellent set of recommendations made at the inaugural meeting in Uppsala, Sweden, 20 months previously (IDRC-MR 168e, pp 62-66). Dr. Belayneh commented on a few of these recommendations; Doggett, in his 'Wrap-up', went through a number more, asking the question each time "what action has actually been taken?" Some of this may be illustrated:

I) Published information

(R1) "It was recommended that the Agriculture Canada Research Station, Saskatoon, update and produce the Brassica bibliography that was last produced in 1980. Details are to be worked out between the Editor from Saskatoon and the Network Advisor through Dr. Downey." WHAT ACTUALLY HAPPENED? WAS ANYTHING DONE?

II) Newsletters for Brassica Information

(R2) "Participants who write short research papers should submit them to the Cruciferae Newsletter and the GCIRC Bulletin." HAVE ANY BEEN SUBMITTED?

III) Germplasm

(R6) "Seed of each released variety (of non-winter Brassicas) be sent from each country, either to Ethiopia, or to Canada, or to both countries. This seed will then be available to participants on request". AN EXCELLENT RESPONSE: 63 ENTRIES RECEIVED - OF WHICH 31 CAME FROM INDIA - WERE MULTIPLIED AND REDISTRIBUTED TO MEMBERS.

(R8) "It was further agreed that Dr. Downey would update the list of Brassica varieties that his colleagues have already compiled .... This list will be sent to the Network Advisor and to the Brassica Committee Chairman." DR. DOWNEY STATED THAT THIS HAD BEEN DONE.

IV) Training

(R12) "Participants from Pakistan, China, Canada and India indicated that such training could be organized in their countries". NO TRAINING YET ORGANIZED.

V) Collaborative research

(R28) "It was recognized that collaboration in research among these countries i.e., those with an Orobanche problem would result in more effective research on the dangerous parasite". A CONSULTANT STUDIED THE OROBANCHE SITUATION IN NEPAL, BUT AS WITH OTHER TECHNICAL MATTERS, HOW CAN THE NEEDS BE CO-ORDINATED?

Doggett then went through the others in the list of 31 recommendations. In virtually all other cases, the situation was as in the exchange of telegrams between Shinyanga and Dar-es Salaam: "Swarm of locusts arrived in Shinyanga 08.00. Usual action taken". "Wire action taken". "No action".

The point being made was simple: the group produced an excellent set of relevant recommendations: but is there a mechanism for implementing them? The two co-chairmen are both very busy men, leaders of programs and heads of departments. The staffing situation needs looking at. A sub-Net is a waste of money: it must be a sub-netWORK.

Country Presentations

India

All India Coordinated Project: Testing of varieties and other elite material is done in the All India Coordinated trials at 25 main centres and 52 testing centres. Mean performance across locations is, therefore, a rather reliable figure, and can be given confidence limits. Brassicas are being tested southwards from Maharashtra and along the cost of A.P. Performance and adoption are both encouraging, especially for mustard (*B. juncea*). Over India as a whole, the trials show good productivity increases. Some frost resistance is now available. More attention is now being paid to cropping systems: as so often, yield is much affected by plant stand. A new seed drill is showing promise.

Pantnagar: The mustard cv's Kranti and Krishna, together with the Toria cvs PT 30 and PT 303, were released. PT 507B is about to be released. Two yellow sarsons, PYS 6 and PYS 841, are also ready for release. Efforts to establish a male-sterile with a suitable maintainer continue, as does the development of dwarf varieties. Oil quality is being improved, and there are strong programs breeding for pest and disease resistance. In entomology, some 40 pests have been identified. Among these, resistances to the following pests are being incorporated: mustard aphis; a sawfly: a painted bug; a leaf miner; and a hairy caterpillar. Losses from these pests can lie between 50 and 85 percent of the crop. For aphis and saw-fly, food preference and plant-part preference are important: screening tests have been developed based on growth and development, food choice, and production of honey-dew: biochemical and physiological characters (such as glossy leaf) have also been assessed in the resistance breeding battle. Much has been learnt about pest management. Attention is drawn to the excellent review by Basudeo Singh and D.R.C Bakhetia, entitled "Screening and Breeding techniques for Aphid Resistance in Oleiferous Brassicae: a Review" (produced by IDRC/Oil crops Network).

In discussion, Dr. P.R. Kumar reported that CR15 and Kranti are both resistant to aphid in the All-India trials.

On the pathology side, seedling blights, *Alternaria blight* (AB), white rust (WR), and downy mildew (DM) are receiving major emphasis. Tolerance to AB from several sources characterized by reduced infection rate appears to be race non-specific. For WR, resistance may be race specific, and some cvs are almost immune. Until further progress has been made in the resistance breeding program, the disease control strategy depends on a combination of integrated use of early escaping or tolerant cvs, and chemical control. AB can be controlled by Iprodione, WR and DM by a mixture of Metalaxyl and Mancozeb.

In the discussion, the occurrence of races in AB was raised, also the prospects of the restoration to widespread popularity of Yellow Sarson if the AB resistance was good enough. The papers by R.P. Awasthi and S. J. Kolte, and that by Kolte, Awasthi and Vishwanath give detailed information.

Comprehensive agronomic studies have been made: I can do no better than to read the section "Possible strategies for increased production" from the paper presented by Arvind Kumar and R. P. Singh:

1. Use of improved varieties, seeds and a time-bound program for varietal replacement,
2. Planting as pure crops at the right time and identifying suitable plant types for mixed cropping,
3. The cultivation of toria and mustard with autumn-planted sugar-cane,
4. The introduction of these crops into suitable cropping systems,
5. The adoption of a remunerative cropping system,
6. Use of the optimum fertilizer dose,

7. Establishment of the optimum plant stand.
8. The adoption of suitable crop protection measures,
9. Where irrigation is limited, replace wheat by mustard,
10. Establish an extensive system of On-farm trials and field demonstrations, and
11. Develop a suitable low-input technology to serve the needs of marginal and sub-marginal farmers.

The transfer of technology is receiving much attention. The productivity of rapeseed-mustard in India is 694 kg/ha, by comparison with the world average of 1262 kg/ha. The relative importance of the components of the package of practices has been analyzed, and increased attention is being given to on-farm trials. It was not clear to me how many of these trials had a strong input from the farmers' side, or whether they were essentially researchers' trials done on farmers' fields.

Target groups of farmers are being identified as representative of the majority on holding size, through surveys. The following four factors are to be considered in designing the on-farm trials:

1. Understanding the farming conditions and farmers' constraints.

2. Knowing the precise objectives of the farmer in a farming system, in order to provide proper weighings for the different treatments.

3. Accomplishing the testing of technology in the farmers' fields while it is still under development, so that there is a greater likelihood of acceptance.

4. Involving extension workers in the research from an early stage. This will improve the level of adoption of the technology generated at the experiment station.

The results and conclusions of the on-farm trials should be considered complementary to the outcome of on-station trials. (Basudeo Singh - Transfer of Technology and on-farm trials of rapeseed and mustard).

I believe that use of these procedures will result in a marked improvement in the farmer-adoption rate. What the farmer himself considers to be worth while to do determines what he actually does.

Dr. L. R. Singh emphasized that future production increases must come from higher yields. Yield gap studies are needed to find out why there are such big differences between the farmers' actual systems and those developed on the Experiment stations which show such good yields? I would suggest that the improved system of farmers' trials just considered will do much to enlighten this problem.

Egypt

A serious shortage of oilseeds lies ahead, and imports will be high. Government resisted the Brassica crops, apparently because of erucic acid. The situation has now been understood, and clearance has been given to grow rapeseed for human food. a screening-cum-breeding program has in fact been operating for some years. Disease resistance and drought tolerance are important: Sclerotinia and white rust are particularly troublesome. Orobanche is widespread, and resistance is needed. Countries sharing this problem will be anxious to exchange seed through the Network.

Ethiopia

Ethiopian mustard (*B. carinata*) has

long been present in the country. There is a strong breeding program, which has recently released six varieties. S-67, S-71, S-115, Awassa Population, Dodolla-1, and Yellow Dodolla. Four *B. napus* cvs from Argentina via Canada have recently been released, one of which is a local selection. The four are: Target, Pura, Tower, and Tower/3.

The approach has three phases:

(i) The development of appropriate technology at research centres, sub-centres, and trial sites.
(ii) Verification trials, both On-station and in representative farmers' fields.
(iii) popularization.

The on-farm activities used S-67, Pura, and a local check. Surveys showed that the majority of the farmers are small-holders practicing intensive cultivation using family labour, and a low level of inputs. The seed-rate is 8-10 kg/ha, there is one mid-season hand-weeding, fertilizer levels vary from zero to 23/15 NP fertilizer.

Good cooperation has been developed with the farmers for testing, and there are On-farm trials at all stages of the program. Such trials have demonstrated that the yields of Ethiopian mustard could be improved to twice or thrice the present levels. The seed yield of Ethiopian mustard is substantially above that of the rapeseed types, but the oil content is lower. Critical factors affecting yields are variety, seed-bed preparation, sowing date, fertilizer application, weed control, and harvesting at the correct stage.

Kenya

The Brassicas do well in Kenya, but the country produces only one-third of its edible oil requirements, the remainder being a drain on the foreign exchange. Introductions have been screened, and Topaz, Gulliver and Niklas have been released: Altex, Westar, Tower, Regent and Oro are ready for release. A Black Leg disease (Phoma) can be serious, but resistance is now available. Resistance to Sclerotinia, and to White Leaf Spot are now being worked on. MOre testing of carinata, juncea, and campestris in the drier, lower altitude areas is needed. However, Brassica production will not "take off" until higher prices are offered to the growers.

China

Brassica is an important crop in the country. There is good cooperation with Canada. Double and single- "zero" types are being screened, and developed. Good material of these is available, with high oil-content, also high linoleic acid content, Some of these lines possess resistance to Sclerotinia, and to viruses. Oro, Tower, Westar, and Topaz already occupy some millions of hectares. Three single zero napus lines have been released. (The glucosinolates are a greater disadvantage than is erucic acid. The former render the cake useless: the latter has always been present in the traditional varieties, and consumers are accustomed to it). Breeding work is going on at several centres; combining ability studies and heritability studies are in progress.

Nepal

The rapeseed area in the Tarai lowlands is being increased. The ecological situation is similar to that of nearby areas of India, where variety development and cultural practices have already received much research. Orobanche could be serious: the problem is being tackled by resistance breeding and crop rotation.

Bhutan

Oilseeds are gradually gaining in importance. Screening of introductions, and cropping-pattern trials, are in progress. Production of oilseeds (all kinds) totalled 1900 mt in 1981, 3,700 mt in 1986. The three major oilseeds are mustard, groundnut, and niger. In 1984, mustard occupied 12,320 acres, groundnut occupied 0.5% of the net oilcrops area. No figures were quoted for niger.

Canada

Dr. Downey gave a brief report. Rapeseed occupies 7-9 m. acres. Good hybrid vigour is expressed in certain crosses. There are pollination problems: hybrids able to give +40 percent yield increase in practice give only +5-10%. The sterile cytoplasm reduces the yield of the female parent by some 10-15%. The next round of hybrids will be better combiners with that particular male sterile. The napus cross uses sterile cytoplasm from a distant relative. Hybrids will soon be in commercial use.

Dr. Downey reported that the cooperative agreement between India and Canada for work on the Brassicas had just been signed.

Germplasm

Dr. J.M. Engels reported that IBPGR is assuming responsibility for keeping the base collections: mandating to the IARCs had not been very satisfactory. There will be global crop networks, based appropriately: he himself is IBPGR Coordinator for South and S.E. Asia, based in Delhi. IBPGR wants the crop breeders involved, and will appreciate advice on collecting needs. conservation of genetic diversity, conservation of seed, documentation, exchange of germplasm, and training will all be important functions. There may be funds available for specific crop germplasm projects.

This series of sessions showed that steady progress is being made on Brassica improvement and productivity. It was particularly pleasing to me to note the farmers' opinions on recommended improved varieties and practices. This was especially the case in India and Ethiopia, and represents an important advance.

REPORT ON A TOUR TO OILSEED BRASSICA GROWING AREAS OF INDIA

Getinet Alemaw

A tour was organized to oilseed *Brassica* growing areas of India by the Oilcrops Network Project (IDRC) in conjunction with the second Brassica subnetwork meeting in Pantnagar 4-6 Jan, 1989. Scientists Participating in the tour were from Bhutan, P.R China, Ethiopia and Nepal. The tour was organized and led by Drs. Basudeo Singh and P.R. Kumar,

Mixed and intercropping are common practices and irrigation (both power and gravitational) is intensive. Extension work and link between researchers and farmers is strong. At many sites studies on yield limiting factors show that application of full package is important. Among individual factors, application of fertilizers followed by disease control were very influential.

Kanpur

At this station, the cropping sequence of toria, maize, wheat, fallow etc. was studied. The best performance of toria was obtained when toria was grown after lubia. Also the best stage of harvest of toria was found to be at yellow pod stage. Intercropping of wheat with mustard is very common. Some varieties are better for intercropping than others. The best row combination ratio and the right variety need to be studied. The variety Rohini gave the highest yield when sown in 1:9 ratio with wheat. All agronomic packages were as to the wheat crop. The effect of foliar application of fungicides on the incidence of Alternaria leaf spot was also on test. Application of Dithane M-45 at the rate of 0.2% a.i/ha was performing better than other treatments.

Morena Farm

The demonstration site showing farmers' practice versus researchers' packages was visited. Mustard was sown with full packages and farmers' method. The best performance was observed with full packages and improved variety. Among individual factors was the use of fertilizer followed by disease and pest control. Alternaria leaf spot and white rust are important diseases for the area. Leaf spot was successfully controlled by foliar application of Dithane M-45 at the rate of 0.2% a.i/ha which showed excellent performance over the untreated check.

Harayana Agricultural University Hisar

Breeders are working on *Brassica juncea, B. napus, B. campestris* var. Toria and *B. carinata*. The department has also a small gene bank. The oilseed team is consisted of breeders, entomologists, agronomists and soil scientists. Here *B. carinata* is thought to be resistant to aphids, white rust and Alternaria leaf spot. They claimed seed yields upto 40 q/ha with oil content of 34% and maturity duration of 160 days.

Azotobacter strains are being studied on Indian mustard, Yellow sarson and toria. Its effect being the increase of nitrogen uptake and thereby the decrease of disease incidence and farm cost. Mycorhiza fungus was also found in roots of Brassica oilseeds. Mycorhiza increases phosphorous uptake and disease incidence particularly root diseases. However, its economics as well as effect on all agronomic characteristics are under scrutiny. So far, it seems that bio-fertilizers are economical.

National Bureau of Plant Genetic Resources (NBPGR)

The bureau has the following organizational set-up.

1. Plant Quarantine Division: Includes pathology, entomology and nematology. The division uses microscopic technique, disinfectant and even x-ray. The division prepares check lists of pests and pathogens to serve as background information. The bureau. releases only healthy seeds for experimentation.

2. Germplasm Evaluation Division: The division evaluates all exotic, and local collections made through exchange and exploration for various crops. The evaluation data is stored in documentation facilities which are equipped with IBM PC.

3. Germplasm Conservation Division: This branch conserves accessions in cold storage facilities. The division also conducts seed physiology studies in relation to storage.

4. Exploration and Germplasm collection Division.

5. Germplasm Exchange Division.

6. National Faculty for Plant Tissue Culture: In this division proper culture and plant environment for important crops including medicinal plants are studied.

7. The experimental farm deals with *Brassica napus, B. oleracea, B. carinata and B. juncea.* Artificial synthesis of *B. oleracea and B. nigra.* When B. oleracea was used as female plants were dwarf with weak stem and lodges badly. Plants were tall with strong stem when *B. oleracea* was used as pollen parent. The bureau scientists believe that *B. carinata* is late but resistant to diseases and pests. Thus, mutation breeding to generate early plants is underway. Some early lines are obtained but they are dwarf with reduced number of branches and pods/plant.

DISCUSSIONS AND RECOMMENDATIONS

A. Brassica Sub-network, Chairman's Report

In the past decade oilseed Brassica has undergone the most rapid expansion in area and production. Until recently much of the research on the crop has been concentrated on selected problems of interest to single scientific disciplines. It was the research on breeding and crop protection of oilseed Brassica that first led to the conviction that there should be close collaboration among the African and Asian scientists. When the regional Brassica sub-network was established in May 1987, germplasm exchange, information exchange and training were identified to be potential fruitful areas for collaboration.

The participants discussed with Dr. Hiruy Belayneh (Chairman) and Dr. Basudeo Singh (Co-chairman) the activities of the sub-network after the first meeting. Dr. Hiruy highlighted the achievements as follows:

1. Seed registry

The regional activity was started with the preparation of the seed registry. Breeders from some of the member countries made available the update list of varieties that have been released so far for future references. This compiled list will be updated and published in the Oilcrops Newsletter.

2. Germplasm exchange

Sixty-three oilseed *Brassica* varieties were collected from China, Ethiopia, India, Nepal and Sweden through the Oil Crop Network Project and distributed back to those who contributed to the nursery.

3. Training

National programs were able to contact each other to organize specialized training where the expertees are available. One Ethiopian Field Assistant got his training at G.B. Pant University, Pantnagar on oilseed Brassica improvement. A technician from Nepal is now being trained at the same university.

4. Information exchange

The member countries were sharing information through Oil Crops Newsletter, Cruciferea Newsletter and GCIRC Bulletin. The last and present Brassica sub-network workshops are also useful forums for information exchange. The first workshop was focussing on status and strategies of oilseed Brassica research while the theme of this second meeting is on technology transfer.

A monograph that reviews and brings together the known information on aphid screening and breeding methods has been prepared by Drs. Basudeo Singh and D.R.C. Bakhetia and distributed to member countries. It has been compiled for Brassica researchers for their consultation and guidance.

The Brassica researchers from Ethiopia and Egypt were able to share the information on Orobache situation in Nepal. The study was thorough and the write up was excellent.

B. Collaborative Research

1. Because of more participants from more countries, the list of relative priority of Brassica research topics (Proceedings of the 1st meeting, IDRC MR168e, 1987 page 57) was updated in Table 1.

2. Coordination aspects are the responsibility of the Chairman and Co-chairman. Each country should submit their requirements/ suggestions to them.

3. A follow-up action on the Orobanche problem should be stepped up. India, Nepal and Egypt should send resistant material to the Network Advisor for redistribution.

4. Information on Sclerotinia will be circulated by Dr. Downey.

5. Specific nurseries are not recommended at this stage. Such nurseries would be constituted once the program develops. The present material exchange system will continue as a kind of collective nursery whereby each member country will send to the Network nursery 500g seed of at least 3 released varieties and 6 breeding lines. This material will be redistributed to contributing countries. Government regulations and quarantine requirements will be fulfilled.

6. For member countries who have mutual interest on specific problems, a cross-border nursery exchange is advised depending on quarantine regulations. Bilateral issues among centers on CMS line exchange for hybrid production was left for the respective member countries (China, India and Canada).

Table 1. Relative priority of Brassica research topics in national projects, updated January 1989.

	Countries											
Subject area	Egypt	Ethiopia	Kenya	China	India	Pakistan	Ban'dsh	Nepal	Canada	Sweden	Bhutan	Cyprus
1. Sclerotinia	2	-	1	3	1	1	-	1	3	1	-	-
2. White Rust	2	2	1	1	3	1	?	2	1	-	1	-
3. Downy Mildew	-	2	1	2	2	1	?	2	-	-	-	-
4. Powdery Mildew	2	-	-	-	-	1	?	-	-	-	-	-
5. Alternaria	1	2	2	1	3	2	1	3	1	-	2	-
6. Black Leg	-	1	2	1	-	-	-	-	3	1	-	-
7. Aphids	2	2	3	2	3	3	?	2	-	-	3	1
8. Orobanche	2	2	-	1	1	-	?	3	-	-	-	-
9. Weed Control	-	-	-	-	-	-	-	-	-	-	-	-
10. Drought	3	1	2	1	2	2	-	-	2	1	-	-
11. Salinity	3	-	-	3	2	2	-	-	1	-	-	-
12. Frost	-	2	-	3	2	1	-	1	2	3	2	-
13. Plant Type	2	2	1	3	3	2	-	2	1	-	1	2
14. Hybrids	-	-	1	3	3	1	-	-	3	-	-	-
15. Quality	3	1	-	2	-	?	?	-	3	?	-	-
16. Seed Drill	2	2	1	2	1	?	?	2	-	?	-	-
17. Alkalinity	2	2	3	3	-	?	?	-	-	?	-	-
18. Village Processing	-	2	3	3	2	?	?	-	-	?	3	-

Priority rating: 3 = high;
2 = medium;
1 = low;
- = not a priority;
? = no information.

C. Other Recommendations

1. Four publications should be prepared before the next meeting and distributed to all Brassica workers:

a) A review of relevant literature on "Alternaria resistance" to be prepared by Dr. S.J. Kolte and Dr. Basudeo Singh.

b) A review of relevant literature on "drought resistance" to be prepared by Dr. Arvind Kumar and Dr. J.N. Sachan.

c) A colored technical bulletin on diseases and insects of Brassica to be prepared by Dr. S.J. Kolte, Dr. G.C. Sachan and Dr. D.R.C. Bakhetia.

d) A review on the Orobanche situation in Ethiopia to be prepared by Dr. Hiruy Belayneh and his colleagues in Ethiopia.

2. A training course on Brassica production (agronomy/breeding) to be organized at Pantnagar, India, for one month (December 1989). Trainees from participating countries (2 each and not to exceed 20) will be nominated by their respective governments. Dr. Basudeo Singh volunteered to organize the ourse.

3. Depending on the funds available, a quality training may take place in China in 1990.

4. Each country will be asked to nominate a contact person to be the link with the Network and Sub-Networks.

5. The next meeting is to be held in China along with the Chinese Rapeseed Symposium, which is expected to be held April-May 1990 at Shanghai.

Part 2.

Other Oilcrops Subnetwork-I

Hyderabad, India
14-15 January, 1989

SAFFLOWER RESEARCH AND COORDINATION IN INDIA

V. Ranga Rao

Although safflower has been under cultivation in India since times immemorial either for its orange red dye carthamin extracted from its flowers and/or oil, the crop received practically little attention until early 70's. The extension of the All India Coordinated Project on Oilseeds which initially started in 1967 to hitherto neglected crop namely safflower gave a fillip to the research and developmental efforts in the crop. Since inception, the number of active research centres on safflower in the country have gone up from 4 to 7 and the network expanded to several non-traditional areas (Madhya Pradesh, Uttar Pradesh, Rajasthan) and situations. Besides, with effect from 1977 a fulfledged Project Coordinator has also been provided exclusively for safflower with headquarters at Solapur (Maharashtra) for the purpose of coordination and monitoring of research activities in the crop. Realizing the crucial importance of genetic resource conservation, documentation and evaluation, the ICAR has also set up a Germplasm Management Unit at the Headquarters of Project Coordinator (Safflower) since VIth Plan.

The last two decades of organized research activity in safflower has indeed been very rewarding; it opened several hitherto unknown and untapped opportunities for improving the yields and incomes of dryland areas and augment the country's edible oilseeds production. Extensive trials carried out in different parts of the country for the first time brought out the superior potentials of safflower as an entire crop under receding moisture conditions. In fact, in a number of areas both conventional (Maharashtra, Karnataka, Andhra Pradesh) and non-conventional (Eastern Uttar Pradesh, Bundelkhand, South-Eastern Rajasthan, Plateau region of Bihar) cultivation of safflower proved far more paying and stable than a number of popularly grown winter season crops like chickpea, linseed, coriander, Herbaceum cottons, wheat etc., in drylands.

The impact of these findings on prevailing cropping patterns is clearly discernible in several parts of the country now identified as proven and efficient areas of safflower culture. What is more, a number of feasible and profitable two crop sequences identified for different rainfed areas in the country either on contingency basis or regular pattern (assured rainfall areas) also include safflower which is known for its ability to tap moisture from deeper layers as one of the important component after either a short duration rainy season cereal (sorghum, pearl millet, maize, rice) or grain legumes (green gram, black gram, groundnut, soybean) and non-legumes (sesame). This indeed brightened the prospects for making productive and profitable use of vast stretches of sorghum and soybean fallows currently under utilized in the peninsular region.

Wealth of data generated in recent years also point out safflower with its characteristic rosette habit and deep and efficient rooting system to be an ideal intercrop with a number of post rainy season crops. Thus, inclusion of safflower as an intercrop with coriander, wheat, linseed, gram at pre-determined row proportions of 3:1 or 2:1 or their multiples has not only registered higher land equivalent ratios in excess of unity but also produced extra monitory returns to the tune of Rs.1000 to 2500/- over and above what is realized from the base crop. The popularization of such simple and synergistic crop combinations are expected to lead to sizeable expansion in the acreage under safflower and bring about greater stability to yields and returns from dryland areas in the country.

Equally rewarding are the researches on the breeding and agronomic front. Since 70's the country has developed 13 high yielding varieties of either location specific or multi regional importance with genetic potentials of 2-3 tons/ha. Breeding programs launched in non-traditional areas for the development of spineless varieties of safflower with high yielding potentials have yielded a number of valuable materials of considerable importance.

Simple low-cost practices such as planting at the recommended time and varietal choice have been demonstrated to have significant bearing on the incidence of insect pests and diseases and their management in both rainfed and irrigated areas and returns from costly inputs like fertilizers, chemical plant protection. Even in drylands, application of fertilizers turned out to be a very critical factor in safflower production. Yields and returns from rainfed safflower registered 40 - 50% increase if one supplementary irrigation is provided at sensitive stages of crop growth or when crop encountered moisture stress. Under constraints of water availability in irrigated canals/reservoirs shifts in crop choice from much preferred water intensive crops like wheat to safflower culminated in higher yields and incomes per unit area, water and input.

The prevailing per hectare yields of safflower in the country are very low ($\leq$ 500 kg). Added to this, there are wide regional disparities in the productivity levels. Results of on-farm trials available from different proven and potential areas of safflower culture in the country reveal existence of vast untapped yield reservoir. According to these, the per hectare yields of safflower even with the technologies currently available, could easily be stepped up to 1 to 1.5 tons/ha in rainfed areas and 1.5-2 tons/ha and above in areas with assured moisture or limited irrigation.

The area, production and productivity of safflower in the country has witnessed remarkable growth in recent years, thanks for the concerted research and developmental efforts. Since early 60's its acreage nearly doubled and production went up by 6.6 fold. While, no doubt, safflower holds tremendous potentials for stepping up yields and returns from dryland areas in the country and thereby impart stability to its production, a number of biotic constraints (Alternaria leafspot, aphids, wilts and root rots) limit realization of its true potentials. The unduly late maturing habit of the currently available varieties in areas with prolonged winter, their poor adaptability to salt affected areas and irrigated conditions, intense spiny nature are some of the other drawbacks limiting expansion of safflower to potentially new areas and situations. The future of safflower in the country and its expansion into newer areas would greatly depend on overcoming these and various other constraints and make its cultivation more attractive and production costs less. Rightly major thrust in the country's on-going research program is for incorporation of genetic resistance against Alternaria leaf blight, aphids in rainfed safflower and Alternaria, aphids, wilt and root rots in irrigated safflower. Various other areas which are currently receiving attention on the research front are:

1. Upgradation of seed oil content in the available improved agronomic base (existing=30%).
2. Development of high yielding varieties of safflower both spiny (traditional belt) and spineless (non-traditional areas) with in built resistance to insect pests and diseases, suited to different situations (irrigated/rainfed, salt affected areas).
3. Exploitation of hybrid vigour.
4. Refine the agronomy of various proven and profitable sequential, relay and intercropping systems for ensuring efficient use ofinputs per unit area and time.
5. Integrated management of insect pests and diseases, and
6. Perfect the agronomy of safflower under limited irrigation in vertisols.

With these and the anticipated developments, the safflower scenario in the country is expected to undergo rapid changes in the coming few years and its contribution to the country's vegetable oil pool increased substantially.

HIGHLIGHTS OF THE SECOND INTERNATIONAL SAFFLOWER CONFERENCE HYDERABAD, INDIA FROM JANUARY 9-13, 1989

V. Ranga Rao

The Second International Safflower conference was held in India, the world's largest safflower growing country, from January 9-13, 1989 i.e. a gap of more than seven years after the first conference in Davis, University of California, USA (July, 1981). The venue of the conference was the historical city of Hyderabad, the capital city of Andhra Pradesh located in the heart of the country's safflower belt. The conference was organized by the Directorate of Oilseeds Research (ICAR) under the joint auspices of Indian Society of Oilseeds Research, a professional body of Oilseeds Workers engaged in research, development, processing, marketing and utilization of various oilseed crops. A number of international and national organizations like the International Development Research Centre, Food and Agriculture Organization, Cargil, MAHYCO, Indian Tobacco Company Limited and Bombay Oil Industries both from Private and Public Sectors co-sponsored the conference.

As compared to the limited participation in the first conference (total number of participants = 79), a large number of safflower growing countries in the world (17) both from the ancient centers of culture and recently adopted homes/centres in the five continents were represented in this conference; these include:
America: Canada (2), USA (3);
Oceana: Australia (2);
Asia: Pakistan (3), Turkey (1),
Iran (2);
Africa: Kenya (1), Tanzania (1),
Morocco (11), Egypt (1);
Europe: Italy (2), UK. (1).

Dr. M. V. Rao, Special Director General, ICAR, inaugurated the conference. One of the highlights of the opening session on 9th January was the presentation of a key note address "Global Perspectives of Safflower" by world's renowned scientist and the father of safflower Dr. P.F. Knowles, formerly Professor of Eminence (Agronomy), University of California.

The deliberations of the conference were spread over 7 technical sessions and covered a wide range of aspects, viz., (1) safflower in different countries (2) genetic resources conservation (3) genetics and breeding (4) agro-production (5) agro-protection (6) marketing, processing, utilization and production development and (7) food chemistry and nutrition.

Besides these, the program also provided for two panel discussions on areas of topical interest, viz., development of hybrid safflower; current status, problems, prospects and future priorities/thrusts (10th Jan.) and global perspectives of combating diseases with specific reference to alternaria leaf spot; current status, approaches and priorities (12th Jan.).

The conference indeed elicited a good response. There were in all 66 presentations of which 52 were oral presentation and others in the form of posters. The bulk of the presentations referred to above were in Session-I (16); III (15); V (8). The conference indeed provided a good forum for indepth discussions and exchange of ideas, information and experiences on various facets of safflower research, development, marketing, processing, utilization and production development and identifying future research thrusts and critical areas of interest for global cooperation.

Based on the five day deliberations the conference made a number of recommendations of a considerable global importance and also suggestions/strategies for the development of safflower in the future. These, interalia, include:

1. Establishment of a global Safflower Advisory Committee on Genetic Resources with representation from major regions/centres of safflower production and genetic diversity.

The newly constituted committee consists of:

1) Prof. P.F. Knowles, (USA) Chairman
2) Dr. V. Ranga Rao, (India) Secretary
3) Prof. Dajue Li (China) Member
4) Dr. Hiruy Belayneh (Ethiopia) Member
5) Prof. A.Ashri (Israel) Member
6) Dr. R. Johnson (USA) Member

The conference empowered the committee to formulate its terms of reference in areas of relevance/interest, viz., coordination of germplasm acquisition and setting priorities for collection, organization of a network of active and base collection, establishment of a network of global data base including information on collection, characterization and evaluation, revision of descriptors list, establishment of strategic research priorities, identification of training needs etc.

2. Setting up of an institute for all the neglected oil crops other than groundnut and soybean through the initiative and support of IDRC.

3. Organization of international screening nursery and cultivar testing through collaboration and support of IDRC.

4. Publication of updated hand book on diagnostic characteristics of various insect pests and disease of safflower through the support of FAO, IDRC and other funding agencies.

5. Documentation of available genetic resources in the world with the help of Directorate of Oilseed Research, Hyderabad.

6. Bring out safflower newsletter with the support of FAO, IDRC and other interested funding agencies.

7. The conference resolved to hold the 3rd International Conference on Safflower sometime in July/August, 1993 in China (Priority-I) or alternatively Australia (Priority-II).

COORDINATED RESEARCH EFFORTS AND LINSEED (*LINUM USITATISSIMUM* L.) IMPROVEMENT IN INDIA

Mangala Rai

Background

In the beginning, considering Oilseeds as a commodity, All India Coordinated Research Project on Oilseeds came into being in 1967 with 32 research centers located in different parts of the country and the Coordinator's Headquarters at IARI, New Delhi. Out of these, four centers were vested with the mandate for linseed improvement. In 1977, the Directorate of Oilseeds Research with its Headquarters at Hyderabad and Associate Project Coordinator (Linseed) unit at IARI, Regional Research Station, Kalyanpur, Kanpur, came into existence. Later on, the Project Coordinator's position was created and the unit was shifted to CSAU of Agriculture and Technology, Kanpur W.e.f. August 13, 1981, and four additional linseed centers were sanctioned. During 1986, six new centers were further added and a multi-disciplinary research approach was adopted at all the 14 centers by strengthening plant breeding, agronomy, plant pathology and entomology disciplines.

Under the coordinated system, promising cultures are evolved in different agro-climatic conditions and are evaluated in multi-location trials at about 30-40 sites in the country. After 3 years of rigorous testing, promising varieties are recommended for adaptive trials and based on their performance in the farmers' fields varieties are released and notified after which effective breeder, foundation and certified seed production programs are undertaken.

Research achievements

Collection, conservation and evaluation of germplasm and its effective utilization through varietal development is an important program under the coordinated research system. As many as 2822 cultures were evaluated for their reaction to rust and powdery mildew diseases and 16% of the total germplasm was found free from rust, Table 1.

Table 1. Classification of linseed germplasm for their reaction to rust and powdery mildew diseases

Disease	Category					
	Free	Resistant	Moderately resistant	Moderately susceptible	Susceptible	Highly susceptible
Rust	452(16.0)	344(12.2)	362(12.8)	525(18.6)	1029(36.5)	110(3.9)
Powdery mildew	27(1.0)	55(1.9)	158(5.6)	337(11.9)	2095(74.2)	150(5.3)

Note: Figures in parentheses denote percentage to the total germplasm evaluated.

In case of powdery mildew, 27 cultures were free which comes to be only 1% of the total germplasm evaluated. As many as 344 and 55 cultures showed resistant reactions to rust and powdery mildew which come to be only 12.2 and 1.9%, respectively. More number of germplasm exhibited susceptible reaction to powdery mildew than to rust.

The list of cultures showing immune and/or resistant reaction to both diseases is presented in Table 2.

Table 2. List of linseed cultures showing resistance to rust (Melampsora lini (pers) Lev.) and powdery mildew (*Odium lini* Skorie)

Free from rust and powdery mildew	Resistant to rust and powdery mildew	Free from rust and resistant to powdery mildew		Free from powdery mildew and resistant to rust
5/3	57-1-62	4/35-1/1-5	Seebhee	Afgan R-1
Bisan	175-1	4/47-2/1-10/1	UD-6	EC-15899
EC-41631	AC. No. 275	56-510	UPC-25	H-627-2
EC-41638	Afgan-8	BR-20	EC-41706	
EC-158978	EC-5194	CP-White	EC-14599	
EC-158981	EC-41481	EC(A)32/64	EC-13988	
EC-158985	EC-41495	EC-1497	IC-41737	
EC-158986	EC-41524	EC-41496	5/1	
EC-158987	EC-41704	EC-41509	EC-41797	
EC-158988	EC-41767	EC-41741	KL-43	
EC-158989	EC-109357	EC-156773	DPL-20	
EC-159005	KL-43	EC-158976	LHCK-172	
EC-159009	RLC-1	EC-158982	AC>No. 2434	
EC-159012	RLC-5	EC-158995	EC-157050	
Fx-13	EC-22586	IIL-6		
Ireland	KL-37	IPL-5		
KB-16-10	BAULK-8	Indore-10		
Maheba local		Kanpur-41/52		
Mirzapur		Daiwas		
N-10		NP-93		
NE-12-2		NP(RR) 447		
UD-3		PT-5-5		
NP(RR)68		R-1163		
EC-158993		AC.No.22		

It could be seen that as many as 24 cultures were free from both rust and powdery mildew diseases at a time. Similarly, 17 cultures showed multiple resistance. Out of the total germplasm evaluated, 36 cultures were free from rust and at the same time, they exhibited resistant reaction to powdery mildew. Also, 3 cultures were free from powdery mildew and were resistant to rust. Here, it is worth mentioning that the powdery mildew resistant culture EC-9832 was utilized extensively in breeding program and a high yielding powdery mildew resistant variety Jawahar - 23 could be developed and notified during 1985 for commercial cultivation in central and peninsular regions of India.

Need for breeding linseed varieties with in-built multiple resistance to prevailing diseases is of prime significance to minimize the risk in linseed cultivation and stabilize the production and productivity per unit area, time and input. It is therefore, hoped that the identified cultures showing free and/or resistant reaction to rust and powdery mildew, will go a long way as potential donors in breeding improved varieties of linseed for commercial cultivation in different agro-ecological conditions.

Tremendous variability in oil and protein contents of seed, iodine value of oil and fatty acid profile was recorded, Table 3. Although there was a negative correlation between oil content and protein content, a few cultures showed an optimum balance where both protein and oil contents were higher primarily at the cost of fibre content of the seed. This indicated that the possibility of improving both the traits simultaneously.

Table 3. Characteristical features of seed, oil and fatty acid profile profile of linseed germplasm

Characters	Range
(A) Seed	
Moisture content (%)	3.5 - 7.7
Oil content (%)	28.3 - 48.8
Protein content (%)	10.4 - 23.9
(B) Oil	
Specific gravity at 34°C	0.918 - 0.928
Refractive index at 34°C	1.4763 - 1.4803
Acid value	0.8- 3.8
Iodine value	155.2 - 195.4
Saponification value	192.4 - 195.7
(C) Fatty acid composition (% wt.)	
Palmitic acid	4.2 - 8.0
Stearic acid	2.2 - 7.9
Oleic acid	15.0 - 35.1
Linoleic acid	8.4 - 27.1
Linolenic acid	36.4 - 61.9

Through concerted efforts, 12 promising varieties for different regions/agro-climatic conditions were evolved by the coordinated network. The salient features of these varieties and their area of adoption are presented in Table 4.
It is hoped that cultivation of these varieties would go a long way in enhancing and stabilizing linseed production and productivity in different agro-ecological conditions.

Under ideal management, 30 q/ha grain yield has been obtained. This potential yield is quite encouraging when compared with the national average which is at a low ebb of about 2.7 q/ha. Replacement of the variety alone has increased the yield over 25%. Intercrop combinations i.e. Linseed + Chickpea, Linseed + Lentil (2:1 to 3:1) and Potato + Linseed (3:1 at 60 cm spacing) have been found most remunerative. Linseed exhibited very high response to fertilization and irrigation when experimented with potato and the net monetary returns with linseed were at par of potato. Row to row distance of 25 cm for seed crop and 15-20 cm for the crop grown for seed and fibre are recommended. It has been realised that the monetary return can be tripled if the crop is grown for both seed and fibre. Under *"Utera"* cultivation, seed rate of 35-40 kg/ha at the paddy dough stage, application of 20 kg N/ha 2 to 3 days before sowing, and crack system of sowing where-ever practiced, has increased the yield significantly.On the average, 22 - 56% increase in yield can be obtained if foliar diseases are controlled with fungicides. For controlling rust, Bavistin (0.1%) or Calaxin (0.1%) or Diathane M-45 (0.25%) have been found most effective. Powdery mildew can be controlled by applying Sulfex or Wetable sulphur (0.3%) or Karathane (0.2%) at 15 days interval depending on the intensity of the disease. For controlling Alternaria blight, seed treatment with Thiram or Agroson GN @ 2.5 g/kg of seed and spray with Diathane M-45 (0.25%) @ 2.5 kg/ha at 15 days interval was found quite effective. Similarly, for wilt, seed treatment with Thiram or Topsin @ 2.5 g/kg of seed and 2 - 3 years crop rotation was recommended.

Among the pests, linseed budfly was rated as most serious where bud damage under heavy infestation or Monocrotophos 20 EC @ 1 litre/ha or Endosulphan 35 EC @ 1 litre/ha at bud initiation stage was found effective in controlling the incidence and increasing the grain yield. Early sowing whereever possible is also recommended.

Research Thrust

Intensive collection and effective evaluation of germplasm for grain yield, fibre yield, components of yield, oil content, components of oil, protein content, iodine value,

Table 4. Linseed varieties evolved through coordinated research efforts in India

Variety	Year of release/ notification	State/Region for which released	Salient features
Jawahar 7	1982	Madhya Pradesh	Dull brown, bold-seeded, resistant to rust, moderately susceptible to wilt, suitable for *Utera* cultivation, matures in 115-118 days, oil content 43%
Jawahar 17	1982	Madhya Pradesh	Brown, bold-seeded resistant to rust, moderately susceptible to wilt and powdery mildew, matures in 115-120 days.
Jawahar 552	1980	Madhya Pradesh	Brown, medium-bold-seeded, resistant to wilt, moderately resistant to rust and powdery mildew, should be preferred for all situations to 'Jawahar 7' and 'Jawahar 17' matures in 115-120 days, oil content 44%.
Pusa 2	1985	Punjab, Himachal Pradesh, Haryana and adjoining areas of Rajasthan, Bundelkhand of Uttar Pradesh, Madhya Pradesh, Maharashtra, Orissa, Karnataka and Udaipur, Kota and adjoining areas of Rajasthan.	Brown, medium-seeded, suitable for rainfed as well as irrigated lands, widely adapted, highly responsive to fertilizer application, resistant to drought and rust, matures in 121 - 155 days in different zones, oil content 43%.
Pusa 3	1985	Punjab, Himachal Pradesh, Haryana and adjoining areas of Rajasthan.	Brown, medium-bold-seeded, highly responsive to irrigation and fertilizer application, and matures, on an average, in 150 days, oil content 43%.
Jawahar 23	1985	Madhya, Pradesh, Orissa, Bundelkhand of Uttar Pradesh, Maharashtra, Karnataka, Udaipur, Kota and adjoining areas of Rajasthan.	Brown, medium-bod-seeded, resistant to powdery mildew, fairly resistant to wilt and rust, best variety to stabilize production in the central and peninsular regions where powdery mildew is serious problem, matures in 120 days, oil content 43%.
Garima	1985	Uttar Pradesh excluding Bundelkhand, Bihar, West Bengal and Assam.	Brown, medium-seeded, resistant to rust and tolerant to powdery mildew, Alternaria blight and wilt diseases, well-suited for irrigated lands, matures in 125-130 days, oil content 42%.
Sweta	1985	- do -	Uneven light-brown, medium-seeded, resistant to rust and tolerant to powdery mildew and Alternaria blight, responds well to medium fertility on rainfed lands, matures in 130-135 days, oil content 44%.

Table 4 Cont'd,

Variety	Year of release/ notification	State/Region for which released	Salient features
Shbhra	1985	- do -	Brown, medium-bold-seeded, resistant to rust, tolerant to Alternaria blight and moderately resistant to powdery mildew, widely adaptable to rainfed and irrigated lands, matures in 130-135 days, oil content 45%.
Gaurav	1987	Uttar Pradesh excluding Bundelkhand, Bihar, West Bengal and Assam.	Double purpose, on an average yields 1050 kg seed and 950 kg fibre/ha, seed fawn coloured, medium bold, resistant to rust, matures in 135-140 days, oil content 43%.
Jeewan	1988	Entire northern belt of the country	Double purpose, on an average yields 1090 kg seed and 1000 kg fibre/ha, medium-brown-seeded, resistant to rust and powdery mildew, matures in 145-180 days, oil content 46%.
Kiran	1988	Bundelkhand of Uttar Pradesh, Madhya Pradesh Maharashtra, Orissa, Karnataka and Udaipur, Kota and adjoining areas of Rajasthan	Brown-medium-seeded, resistant to rust, wilt and powdery mildew, matures in 120-125 days, suitable for rainfed, oil content 43%.

resistance/tolerance to rust, wilt, Alternaria blight, powdery mildew, linseed bud fly, salinity, alkalinity, moisture stress, etc. will be undertaken. Potential donors will be isolated and basic genetic information will be generated. Possibile varieties of evolving edible and technicalgrades will be explored. Keeping prevailing and potential pure cropping, intercropping, relay cropping and *paira* or *utera* cropping systems in view, varieties for intensive input and starvation input conditions will be evolved. For stabilizing productivity and production and enhancing net monetary returns, multiple disease and pest resistance/tolerance will invariably be brought into the genetic system of improved cultivars. Stress tolerant genotypes will be developed to bring more area under cultivation by using presently available waste lands. Suitable plant types will be evolved not only for different cropping systems but also for effective fibre and seed production through double-purpose linseed cultivation. Hybrid linseed production, varietal blends and multiline constilation and its renovation will also receive adequate attention. Matching agronomy and efficient plant protection cover will be worked out. Survey and surveillence for pests and diseases will be strengthened and integrated disease and pest management, preferably through non-monetary inputs, will be attempted. Quality seed production and in turn its effective dessimination will be the ultimate aim. Farmer's field demonstrations will continue to be used as one of the most powerful tools for transmission of improved production technologies.

SAFFLOWER RESEARCH IN EIGHTIES IN MADHYA PRADESH (INDIA)[1]

A.R. Sawant

Safflower research work at Indore (Madhya Pradesh) started in 1979 with financial support from IDRC, Canada, indicated that safflower has considerable scope in the non-traditional states, particularly Madhya Pradesh. The contributions made by the project in safflower research are as follows:

Varietal Improvement

The first high yielding variety developed in the project was JSF-1, which was released in 1984 in the name of Jawahar Safflower-1. This white flowered variety has potential to yield 1500 kg/ha under dry condition and is suitable for the entire Madhya Pradesh and is also doing well in the near-by state of Rajasthan. Quite a few of the new varieties such as JSI-8,9,10,12 & 46 have been developed in recent years and are superior in performance to JSF-1 in different yield trials including multilocation varietal trials conducted in Madhya Pradesh at Indore, Khandwa, Khargone, Dindori, Jaora and Morena. The most promising varieties are given in Table 1.

Table 1. Performance of the new improved varieties of safflower at Indore

Variety	Grain yield* (kg/ha)	1000 grain Wt./(g)	Days to flowering	Plant height (cm)
JSI-9	2019	56	94	78.4
JSI-46	1837	61	85	75.5
JSI-10	1814	62	88	78.0
JSF-1	1747	75	88	68.4

*Based on the last 4 years.

Development of Spineless Varieties

Unlike the traditional areas, the farmers here desire to have spineless varieties as they are not accustomed to the harvesting and threshing of the traditional spiny varieties. In view of this, spineless variety, JSI-7, has been evolved at this centre. It equals the spiny variety JSF-1 in yield and other characters and yields as high as the national spiny check variety, A-1, Table 2. It has been recommended by the All India Rabi Oilseeds Workshop held at Puna in 1988 for release at a state level.

Table 2. Yield comparison of spineless variety JSI-7 with high yielding spiny check varieties JSF-1 (local check) and A-1 (national check) during 1982-84.

Year	No. of trials	Average yield (kg/ha)			% less yield than	
		JSF-1	A-1	JSI-7	JSF-1	A-1
1982	3	2024	1768	1824	9.9	-
1983	3	1867	1576	1531	18.0	2.9
1984	4	1756	-	1497	14.8	-
	Average	1882	1672	1617	14.1	3.3

An Exquisite Spineless Safflower Collection

As a result of intensive hybridization amongst 16 diverse spineless types reported earlier (4), several hundred diverse spineless lines have been evolved at Indore. The most promising among them are presented in Table 3. All thiese spineless materials form the excellent base population for further improvement of spineless safflower.

Table 3. Promising new spineless lines identified during 1987-88.

Entry	Pedigree	Plant height (cm)	No. of branches/ plant	No. of capitula/ plant	100 grain weight (g)	Yield (kg/ha)
Spp. No. 33	WSM-1SP-3 x JSI-7	82	10	36	3.00	3600
Spp. No. 227	JSI-41 x JSI-7	89	5	25	3.55	2222
Spp. No. 228	JSI-41 x JSI-7	81	8	22	4.15	2222
SPP. No. 294	JSI-42 x JSI-7	77	7	17	5.75	2089
SPP. No. 330	JSI-42 x WSM-1-SP-2	84	6	19	4.55	1889

Development of Varieties with High Oil Content

Development of "high oil" varieties (containing more than 35% oil) was started with the introduction of exotic high oil lines from Dr. P.F. Knowles. Good selections showing desirable plant expression were identified from this material and were further crossed to the high yielding spiny varieties. The technique of selection of "high oil" individual plants in the field and testing of their progenies in subsequent season was reported for 2-3 cycles (2). As a result of this recurrent selection for high oil and yield, few promising lines have been developed recently (Table 4).

Table 4. Promising high oil lines identified during 1987-88

	Plant height (cm)	Flower color	100 grain Weight (g)	Yield (kg/ha)
SPP. No. 40	85	Red	3.60	2289
SPP. No. 2029	90	Yellow	5.00	2178
SPP. No. 2000	95	Yellow	3.35	2133
SPP. No. 2027	95	Yellow	4.05	1956

Development of Disease Resistant Varieties

It was observed that, too early planting (1st week of September to mid September) increases the incidence of foliar diseases particularly *Alternaria*. Using the specific nursery in the off-season suggested for screening against foliar diseases 1985) cultures, viz., ESI-31, ESI-24, ESI-21, O.P. (II) No. 10, ESI-22-5 and ESI-19, having tolerance to foliar diseases have been identified (3).

Certain exotic lines resistant to *Phytophthora* root rot and rust were obtained from California, U.S.A. Few selections showing desirable characters and stabilized plant expression have been isolated from this material. These selections are further being evaluated and are used as a source of resistance for the development of resistant varieties.

Development of Aphid Tolerant Varieties

Aphid (*Uroleucon compositae*, Theobald) is the most serious and by far the only major insect problem in safflower in this region. Too late planting (end of October to 1st week of November) increases aphid infestation due to greater succulence of plants at the time of aphid infestation where as early planting is less prone to aphid attack (3). A specific nursery is being used for screening safflower lines in the field against aphid (4).

Field screening of the entire breeding material failed to identify the genotype completely resistant to aphid attack. However, certain level of resistance was noticed in few genotypes. The criteria suggested for selecting for aphid resistance viz., less succulence of leaves and stem, thin woody branches and thick leathery leaves appeared to be effective particularly in spineless safflower population and few tolerant spineless safflower lines have been identified (5).

Control of Aphids by Chemicals

Out of the 4 insecticides viz., Quinolphos, Endosulfan, Phosphomidon and Dimathoate tested for three years (1984 to 1986). Dimethoate 0.05% appeared to be the best as regards effective aphid control and high benefit cost ratio (Table 5).

Table 5. Evaluation of certain insecticides as regards aphid control (Indore, 1984 to 1986)

Insecticide	Decline in aphids (%)	Yield (kg/ha)	Total return (Rs/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Benefit Cost ratio
Dimethoate 30 EC	66.1	1534	6136	1914	4222	2.20
Phosphomidon 76 EC	54.2	1343	5372	1856	3516	1.89
Quinalphos 20 EC	58.7	1435	5740	2158	3582	1.85
Endosulfan 35 EC	42.5	1414	5656	2008	3648	1.81
Control		1059	4236	1664	2572	1.54

Economies of Different Management Practices

1. The complete package of practices followed in safflower (full recommended fertilizersand complete plant protection for aphids) gave highest yield and highest net return (Table 6). Although fertilizer has higher yield and total return than those with plant protection measure for aphids, the latter gave higher net return and benefit-cost ratio. The yield losses due to aphids ranged from 14 to 17%.
2. Provision of only one protective irrigation for germination in the soil moisture stress situation increased the crop yield by about 21% because of optimum plant stand, which is difficult to attain under dry (stress) condition.

Intercropping of Safflower in Gram and Linseed

Sole crop of safflower and intercropping of safflower in linseed or gram appeared to be more remunerative than the traditional sole cropping of gram or linseed

(Table 7). Two rows of safflower could be alternated with 4 to 6 rows of linseed or gram. Here field operation viz., weeding, spraying, harvesting, etc. could be easily done in safflower rows compared to those in sole crop. Hence, such intercropping is particularly useful to farmers who are hesitant to grow sole crop of safflower because of spines.

Table 6. Economics of different management practices (Indore, 1984 to 1986)

Treatments	Total aphids/ plant	Yield (kg/ha)	Yield losses over protected plots (%)	Cost of cultivation (Rs/ha)	Total return (Rs/ha)	Net return (Rs/ha)	Benefit cost ratio
Low monetary input (L.M.I.)	228.3	1303	14.10	1071	5212	4141	3.86
LMI + Plant protection	31.3	1517	-	1321	6068	4747	3.60
L.M.I. + fertilizer	228.9	1574	17.37	1606	6296	4690	2.92
L.M.I. + Fertilizer + Plant protection	29.4	1905	-	1856	7620	5764	3.10

NOTE: 1. Low monetary inputs include timely planting, recommended variety, spacing, seeding rate etc.
2. Dimethoate 0.05% spray was applied once/twice for plant protection against aphids.
3. Fertilizer (full recommended dose) was applied at the rate of N40:P40:K20 kg/ha.

A new parameter for intercropping studies

A new parameter, RYE (Relative Yield Efficiency) has been suggested for studies on intercropping experiments (1). It has the following relationship:

$$RYE = \frac{\text{Yield per unit row of intercrop}}{\text{Yield per unit row of sole crop}} \times 100$$

The new parameter estimated the yield potential of a given crop in intercropping system compared to that under sole cropping. The higher the RYE, the greater is the yield efficiency of that crop under intercropping. In general RYE values were higher for safflower intercropped with linseed than those for safflower intercropped with gram (Table 7). This shows that, yield efficiency of safflower is higher when intercropped with linseed.

Development of New Research Techniques

The following new research, techniques/equipments were developed for safflower research.

1. Quick method of oil estimation.
2. Technique for the selection of "high oil" genotypes in the field.
3. Breeding method for handling early generations.
4. New parameter, RYE for intercropping studies.
5. Specific off-season nursery for screening for resistance to foliar diseases.
6. Specific nursery for screening lines against aphids.
7. Nylon net bags for efficient selfing.
8. Electric single plant thresher for threshing of individual plants.

Table 7. Economics of Gram/Linseed: Safflower intercropping*

Treatments**	Total cost of cultivation (Rs/ha)	Total return (Rs/ha)	Net return (Rs/ha)	Benefit cost ratio	RYE***
G:S 2:2	1787	4606	2855	2.13	(G) 102.5 (S) 107.3
G:S 4:2	1817	4405	2588	1.99	(G) 103.5 (S) 88.2
G:S 6:2	1833	4548	2646	2.03	(G) 82.8 (S) 100.3
L:S 2:2	1703	5442	3674	2.82	(L) 38.6 (S) 157.8
L:S 4:2	1765	5801	3969	2.96	(L) 46.7 (S) 155.7
L:S 6:2	1790	6035	4176	3.14	(L) 65.8 (S) 157.0
Safflower (sole)	1761	6707	4870	3.22	-
Gram (sole)	1699	2428	733	0.21	-
Linseed (sole)	1363	2830	1428	1.76	-

* based on 4 years (1984 to 1987),

** G = Gram; S = Safflower and L = Linseed, 2:2 = 2 rows of base crop (gram or linseed) alternated with 2 rows of intercrop (safflower).

*** RYE = Relative Yield Efficiency.

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NIGERSEED IN INDIA: PRESENT STATUS OF CULTIVATION, RESEARCH ACHIEVEMENTS AND STRATEGIES

S.M. Sharma

Niger (*Guizotia abyssinica* Cass.) is an important oilseed crop grown in many tropical and sub-tropical countries, India, Ethiopia, East Africa, West Indies and Zimbabwe are the important niger growing countries of the world. However, India and Ethiopia are the major producers of niger.

In India niger crop is cultivated mainly in the states of Madhya Pradesh, Orissa, Maharashtra, Bihar, Karnataka and Andhra Pradesh and to some extent in hilly areas of Rajesthan, Uttar Pradesh, Gujarat, and Tamil Nadu and also in some parts of eastern hilly states of the country (Table 1).

Table 1. Area, production and productivity of nigerseed in different states of India.

States	Area ('000 ha)		Production ('000 tons)		Productivity (kg/ha)	
	84-85	85-86	84-85	85-86	84-85	85-86
Andhra Pradesh	11.3	12.3	1.3	3.1	115	252
Bihar	36.0	37.0	13.7	13.6	381	368
Karnataka	64.5	54.9	11.4	9.4	177	171
Madhya Pradesh	219.1	217.3	34.3	47.1	157	217
Maharashtra	96.8	95.9	22.6	20.7	233	216
Orissa	156.5	201.2	62.3	94.0	398	467
West Bengal	5.4	5.4	2.3	2.3	426	426
Dadar & Nagar Haveli	0.4	0.3	0.1	0.1	250	333
All India	590.0	624.3	148.0	190.3	251	305

The important features of this crop are that it gives satisfactory seed yield even under poor growing conditions with little care, effort and expenditure. The crop is resistant to drought and is less attacked by birds, insect pests, diseases and stray and wild animals grazing freely in hill and forest areas.

Uses

Nigerseed oil is of good quality edible oil with pleasant nutty sweet taste. It is mainly used for oil extraction (about 76%) for culinary and anointing purposes. The oil is bluish white in color and is a good absorbant of fragrance of flowers due to which it is used as base oil by perfume industry. Lower grade oil is used for soap making and as illuminant. Nigerseed oil is also used as a paint oil to a limited extent. Nigerseed cake is utilized for feeding cattle or as manure. Nigerseed is a good bird feed and also consumed in certain regions as food (about 18%) and Chutny mixed with chilly and spices.

Climate and soil

Niger requires adequate rainfall in the growing period to get a good yield. A rainfall of 1000-1300 mm is considered to be the optimum. However, 800 mm rainfall, if spread over the growing period, will produce reasonably good yield. Growth is depressed in conditions of above 2000 mm rainfall. The peak flowering period of the crop should not coincide with the rainy period as the honey bees, which are the main pollinators of this crop, are disturbed resulting in a very poor seeding, the crop being almost exclusively cross pollinated by honey bees.

Niger crop is extensively grown on marginal and sub-marginal lands in tribal areas mostly on hill slopes, although the crop does best on well drained clayey loam or sandy clay soils of good depth and texture. It is often grown on stony or lateritic soils mainly because comparatively more profitable crops are grown on better and fertile soils.

Varieties

Improved varieties of niger have been recommended for different niger growing states (Table 2).

Table 2. Recommended varieties of Niger.

State	Recommended varieties
Andhra Pradesh	Ootacamund, Gaudaguda Local
Assam	IGP-76
Bihar	No. 5, Ootacmund
Gujarat	IGP-76
Karnataka	No. 71 (KRN-1)
Madhya Pradesh	Ootacmund, No. 5
Maharashtra	IGP-76, N-12-3
Orissa	Phulbani local, IGP-76
Rajasthan	IGP-76
West Bengal	Ootacamund
Dadar, Nagar Haveli	Ootacamund

The yield potential and other important characteristics of these varieties are as follow:

1. Gaudaguda local: A local variety traditionally grown in coastal hilly tract (Vizianagaram district) of Andhra Pradesh. Plant height 140 cm, profusely branched. The crop matures in 95 days and it has average yield potential of 5.70 q/ha. Seed medium bold (4.2 g/1000 seeds) and black in color with 39% oil.

2. IGP-76 (Sahyadri): A selection from the population of N-12-3 variety from Maharashtra. Released in Maharashtra State. Plant height 170 cm. Fruiting begins from 4th to 6th node of main stem. Foliage green, rough due to coarse minute hairs. Flowers bright, canary yellow. Flowering begins after 70-75 days and the crop matures in 100-110 days. Plants bear 35-40 capitula per plant and with 25-27 seeds per capitulum. The average yield potential is 4.75 q/ha. Seeds bold (5g/1000 seeds), dark brown in color.

3. N-12-3: A local variety developed at Niphad (Maharashtra). Very similar to IGP-76. Seeds medium bold (4g/1000 seeds), black in color with 40% oil. Suitable for Vidarbha region of Maharashtra. With yield of about 4 q/ha and maturing in 110 days.

4. No. 5: Developed by selection from local material of Maharashtra. A photo- and thermo-sensitive variety, which matures in 95-105 days. Non-shattering, seeds bold (4.5 g/1000 seeds), black in color with 40% oil. Moderately susceptible to hairy catterpillar. The variety has average yield of 4.50 q/ha.

5. No. 71 (KRN-1): Developed by selection from local material at Raichur in Karnataka, released in 1981 in Karnataka. Plant height is 120 cm, single capitulum bearing, rarely double capitula, about 50 capitula per plant. It has average yield of 4.75 q/ha. Seed is small (3g/1000 seeds), black in color, with 39% oil, resistant to lodging and drought. The crop matures in 95 days.

6. Ootacmund: Developed by selection from indigenous material at Nagpur (Maharashtra), plant height 160 cm, profusely branched, about 75 capitula per plant. A photo- and thermo-sensitive variety, maturing in 110 days. Seeds bold (4.5 g/1000 seeds), black in color with 42% oil and

average yield of 5 q/ha.

7. Phulbani Local: A local cultivar, traditionally grown in Koraput area of Orissa. Plant height is 151 cm. The crop matures in 95-100 days. Seeds are small (3.4 g/1000 seeds), black in color with 40% oil. Suitable for crop rotation with Ragi, cowpea, frenchbean and little millet. It has average yield of 4 q/ha.

Production Technology

Time of Sowing:

Optimum time of sowing for kharif crop is from mid June to early August; whereas rabi crop can be sown in the month of September. Appropriate sowing time for different states is given below:

State	Optimum time of sowing
Madhya Pradesh	-Third week of July
Maharashtra	-June end early-August
Andhra Pradesh	-Second week of August
Bihar	-Second fortnight of August to September
Karnataka	-June-August

Seed treatment, seed rate and method of sowing

The seed treatment with thiram, captan or other mercurial fungicide @ 3g/kg of seed prior to sowing is recommended to protect the crop from seed borne and to some extent soil borne diseases also.

The seed rate depends on the method of sowing. Generally 5-8 kg/ha seed is required. The crop is broadcasted. However, line sowing has been found to be beneficial. The row spacing ranges from 20-30 cm. Close row spacing (20 x 10 cm) has been found beneficial for the States of M.P., Maharashtra and Orissa. While for Andhra Pradesh and Karnataka 30 cm spacing is advantageous. Thinning should be done to maintain the required plant population after about 2 weeks of sowing. Seed must be sown into the moist soil, but the level of available soil moisture, adequate to sustain germination and varies with soil type. A higher level is necessary in sandy soil than in clay. A seed bed temperature of 17-25°C is the optimum, below 10°C impairs germination and above 35°C results in uneven emergence.

Manures and Fertilizers

The crop is mostly cultivated on marginal and sub-marginal lands having low fertility status and is rarely fertilized. It is mostly raised on residual fertility from previous crops. However, experimental evidences are available to show that niger responds to fertilizer application and on the basis of fertilizer trials recommendations are made. In general, 4 tons of farm yard manure and 20:20 NP/ha is recommended for major niger growing states. Half of the nitrogen and full dose of phosphate fertilizer should be applied at sowing and the remaining half of the nitrogen is top dressed at 30-35 days after sowing. Use of bio-fertilizer on niger crop need to be investigated.

Weed control

Niger grows rapidly once the seedling are established. It is a good competitor with weeds, provided pre-planting operations have removed the majority of the weeds. Two weedings are generally practiced. The first weeding should be done at the time of thinning i.e., about 15 days after sowing. If required, second weeding is done before top dressing with nitrogenous fertilizer.

Dodder (*Cuscuta chinesis* L.) has

become, in some area, a problematic parasitic weed. The weed emerges along with the germinating seedlings and parasitises them soon by attaching itself to the host and bringing down the seed yield by 60-65%. As a precautionary measure, seeds should be obtained from cuscuta-free areas and if cuscuta seed is found mixed with niger, sowing should be done after separating the weed seed by sieving.

Trials were conducted at Bhubaneshwar and Paltangi (Orissa) using selective herbicide pronamide as pre-emergence soil treatment on the next day of sowing and as post-emergence foliage treatment at 20 days after sowing. The results revealed that the control of dodder was about 90-99% by application of pronamide without damaging the associate crop of niger. The yield increase was 109-262% over untreated control with pronamide application, the highest (262.5%) being with foliage treatment at 2 kg a.i./ha.

Irrigation

Niger is invariably grown in the rainy season and it is rarely irrigated. There are indications, from the trial at Jabalpur, that niger yields can be doubled under irrigated condition. There is no information on water requirement and consumptive use of water in niger.

Soil moisture stress at seedling stage affects the growth of niger more severely than other stages. Niger can withstand high soil moisture levels. It has shown some tolerance to saline water also.

Pest Control

Among the many insect pests that feed on niger, about half a dozen pests are economically important. A brief description of each pest along with its nature of damage and control schedule is presented in Table 3.

Disease Control

The major diseases that affect the niger crop and their control measures are given in Table

4. Harvesting

The crop should be harvested when the leaves dry up and the head turns blackish in colour. After drying in sun for about a week by stacking on the threshing floor, the crop is threshed by beating with sticks.

Expected yield

With improved varieties and production technology, yield of about 5-7 q/ha may be expected.

Some New Promising Varieties

Some new varieties have been found promising in the All India Coordinated Trials (Table 5). Testing of these varieties in adaptive trials will reveal their suitability for release for general cultivation.

A Scheme for Breeding Synthetic Varieties of Niger

1. Select single plants on phenotypic basis from available material. Collect open pollinated seed. Divide the seed into two halves.

2. Grow replicated progeny rows from one half of the seeds. Record observations and work out parent progeny correlation (half sibs) and determine genetic correlations between pairs of characters and estimate additive and dominance variance. Screen parental selections on the basis of selection indices. Select

plants with good scores and mix their seed (second half of the stored seed of step-1) in equal quantities.

3. Grow the mixed seed in isolation rogue out undesirable plants before flowering. The seed harvested is a synthetic. Divide the seed of synthetic into two parts. Use one part to provide the base population for the next cycle and the other half for testing against local. This should be done from second cycle onwards.

Table 3. Insect pests of niger and their control.

Common name	Latin name	Nature of damage	Management/control
Niger caterpillar	*Perigaea capensis*	The caterpillar (green with purple markings) feeds on leaves and defoliates the plants.	1. Proper weeding of fields reduces hiding places. 2. Dusting with 10% BHC or 5% Carbaryl or 5% Parathion @20-25 kg/ha or spray Thiodon 35 EC @ 0.07%, Carbaryl 0.1% or Monocrotophos 0.05% or Dichlorvos 0.05%.
Cut worm	*Agrotis ipsilon*	The moth hides under dried twigs and leaves at day and lays eggs on leaves. Larvae attack the crop and eat plants at ground level.	1. Keeping grass bundles or crop refuges in cluster in fields for hiding the caterpillars during day and killing them by dusting 10% BHC or 5% Carbaryl or 5% Parathion dust. 2. Spraying with Carbaryl 0.01% or Monocrotophos 0.05% Dicholorvos 0.05%
Hairy caterpillar	*Diacrisia obliqua*	Major pest in Bihar. The caterpillars remain gregarious underneath leaves in early stages and cause serious loss in yield at 3rd and 4th instar	1. Collection and destruction of egg masses and early instars of caterpillars. 2. Spraying with Dicholorvos 0.05% or Carbaryl 0.01% or Monocrotophos 0.05%. 3. Dusting with 10% BHC or 5% Carbaryl or Parathion @ 20-25 kg/ha.
Semilooper	*Achaea janata*	Major pest in Bihar. The caterpillar is slaty in color, moves by making its half loop, causes severe damage in association with other leaf feeders.	1. Same as in niger caterpillar
Surface grasshopper	*Chrotogonus* spp.	These are usually active in early stage of the crop. These grasshoppers being general feeders, also cause appreciable damage to the crop in its early stage.	1. Dusting with BHC 10% or Carbaryl 5% @ 15 kg/ha control the pest in early stage.

Table 4. The major diseases that affect the niger crop and their control measures.

Disease	Symptoms	Control measures
1. Powdery mildew (*Sphaerotheca* spp)	Small cottony spots on leaves which spread on the lamina followed by defoliation of affected plants in severe cases.	When the disease is noticed spray 0.03% solution of Wetsulf or Sulphur. Repeat after 15 days.
2. Cercospora leaf spot (*Cercospora guizeticola*)	Small straw to brown colour spots on leaves when severe, entire leaf may be covered followed by defoliation.	1. Seed treatment with 0.3% Thiram before sowing. 2. Two sprays with 0.2% Zineb at 15 days interval when disease appears.
3. Alternaria leaf spot (*Alternaria* spp.)	Concentric rings, brown in colour with gray centre, oval to circular or irregular in shape.	As above
4. Seed rot (*Rhizotonia bataticola* and *Sclerotium rolfsii*)	The infected seeds become discoloured. The seedling from such seeds die.	Seed treatment with 0.3% Thiram before sowing.
5. Root rot (*Macrophomina bataticola*)	The roots rot. Black dots appear on the roots.	As above

Table 5. Some promising varieties of niger identified for per-release.

Variety	Centre/State	Maturity (in days)	1000 seed Wt (g)	Yield kg/ha
ONS.4	Semiligude (Orissa)	120	3.06	500
CHH.3	Chhindwars (MP)	110	3.61	500
ONS.8	Semiliguda (Orissa)	120	4.23	500
GA.10	"	117	4.27	600
GA.11	"	115	4.20	500
RCR-140	Raichur (Karnataka)	110	3.96	500
CHH.1	Chhindwars (MP)	110	3.96	500
CHH.2	"	100	4.01	500
DHL.1	Dindori (Nasik) (MS)	102	3.99	500
REC.1	Kanke Ranchi (Bihar)	110	4.23	450
BNC.120	"	107	4.14	450

4. Preserve seed from each cycle. After third cycle, conduct trials of seeds from different cycles. When the last and penultimate cycles do not differ significantly, the adaptive peak has reached and no further selection would be fruitful.

   The synthetics besides being high yielders than the locals, can withstand better in any unfavourable conditions.

Problems that Need Immediate Attention and Proposals to Solve them

1. Niger varieties have low yield potential. Intensive efforts should be made to breed varieties with higher yield potential so that the crop becomes more remunerative and farmers get incentive to put

the crop in a better land and pay more attention to its management. Hybridization progrme should be intensified and synthetics and composites of higher yield potential should be developed.

2. The present varieties are based on narrow germplasm. Every effort should be made to collect germplasm from all parts of the country and abroad.

3. At the scientist level, basic information on the plant characteristics are lacking. Studies on genotype-environment interaction, quantitative components of yield, heritability of different characters and pollinating agents should be done.

4. The crop is essentially a cross pollinated one due to self-incompatibility and studies on seed setting should be done.

5. Improved agronomy of the crop for different agro-climatic regions should be worked out and package of practices should be developed.

6. Impact of improved varieties and improved agronomic practices should be demonstrated so that farmers could be convinced of the yield potential and profitability of this crop.

7. Availability of seed is a problem particularly in tribal areas. Production, procurrement and distribution of seed should be taken upon a top priority basis.

CONSTRAINTS AND OPPORTUNITIES FOR INCREASING THE PRODUCTION AND PRODUCTIVITY OF NIGER IN INDIA

S.M.Sharma

Constraints Limiting Production and Productivity (Factors limiting the yields):

Inspite of its importance as an edible oilseed, the cultivation of this crop is confined to marginal lands under very poor agronomic practices resulting in low average yields. Niger, being a crop of tribal areas, is grown in poor, eroded, hilly soils. Hence low yields of this crop are not surprising. Limiting cultivation of these crops to productive regions only may not be feasible at present. Efforts should be made to identify the causes of low yield in different areas and conditions of cultivations of this crop and seek ameliorative methods. Some of the causes of low yield are discussed below:

(a) Poor plant population:

One of the most important causes for low yield is the patchy stand of the crop which may be due to several reasons including improper seed-bed, seed or soil borne diseases like, Rhizoctonia in niger, soil borne pests etc. Very frequently conditions are so bad that the farmer is hardly able to harvest 50-60% of the sown area. Thus, even with the improved varieties, the production is low.

(b) Moisture:

Being mostly kharif crop it suffers in early stages due to excessive rains and at the later stages results in higher productions. Rain during pollination period hinders pollination resulting in empty seeds.

The principal niger growing states are: Madhya Pradesh, Orissa, Maharashtra, Karnataka and Bihar, although it is grown to some extent in hilly areas of Uttar Pradesh, Rajasthan, Gujarat, Andhra Pradesh and North Eastern hilly areas.

There are new potential areas for niger cultivation in India, a brief account of each follows:

Bihar:

The area climatic conditions prevailing in tribal region particularly in Chhotanagpur and Santhal Parganas are best suited to niger cultivation where it occupies 97.8% of the total area and 97.8% of the state production of niger is obtained from this plateau region. Researches in dryland agriculture have proved that it is a prospective oilseed crop for rainfed monocropped areas of this plateau. Light textured red and brown soils of this region are best suited for niger cultivation.

As a pure crop, niger yields more when sown in the second fortnight of August; September sowing is mostly done in this plateau after the harvest of kharif crops, namely, Ragi, Gorapaddy and black gram, to fetch supplementary income from these crops sown in June.

Additional land available for cultivation in Bihar amounts to 3.8 million/hectares, most of which falls under the jurisdiction of this region. About 2.7 million ha, according to one estimate, will come from the area under barren culturable land, culturable waste land or/and current fallows which can be used for the cultivation of niger. Further, the area under single cropping could also be brought under double cropping with this crop.

Orissa:

Niger occupies a third position among the major oilseeds of the State, with about 19.7% of the total oilseed area under nigerseed.

The niger crop is usually taken as a second crop after short duration crops like *Panicum miliare.* Koraput is the most important district of the State for niger. The other major districts are: Phulbani, Keonghar and Mayurbhanj and Ganjam.

In Orissa there is a vast culturable barrier and waste land which can be utilized for the cultivation of niger in these districts and in other adjoining districts. In this state it would be profitable to popularize niger crop in culturable waste and barren lands where *cuscuta* is not yet a problem, because the area under this crop is dwindling.

Madhya Pradesh:

In Madhya Pradesh, nigerseed is grown in an area of about 2.75 lakh hectares mainly in the districts of Chhindwara, Mandla, Sarguja, Seoni, Raigarh and Shahdol. The largest quantities of nigerseed are produced in the districts of Mandla, Chhindwara, Seoni, Sarguja, Raigarh, Betul and Baster. There is a large marginal forest and waste land in these tribal areas which can grow a good crop of niger. Much additional land can be brought under this crop in tribal areas of Bilaspur, Bastar, Sarguja, Sidhi, Shadol and Rawa districts.

Maharashtra:

Nigerseed is grown in an area of about 95 thousand hectares in this State. Osamanabad and Nasik are the largest nigerseed producing districts of the State. Other potential districts are Nanded, Beed, Parbhani, Pune and Dhule, where sizeable area is already existing and the crop can expand to new hitherto uncultivated areas in these districts. Thane, Ratnagiri, Amednagar, Kohlapur and Stara districts where large barren and culturable waste land is available in hill areas can also increase in their area under nigerseed.

Karnataka:

Nigerseed is grown in about 54 thousand hectares in this State. The largest niger growing districts are Bihar and Gulbarga. The other districts having sizeable area under niger are Mandya, Mysore, Raichur, Bangalore, Hassan, Ballary Chitradurga, Tumkur and Dharwad. These districts have large culturable waste and barren lands which can be diverted to nigerseed. Nigerseed can be grown more profitably as a late sown crop in monsoon season when the sowing of other crop can not be done.

Andhra Pradesh:

Nigerseed is grown mostly in Rastakuntubai region of Vijayanagram. It is also grown in Chittoor, Rangareddy and Medak districts. Here expansion of its area is possible. The crop can also be profitably grown in tribal areas of Khammam and Warangal districts of Telangana region. Similarly, Anantpur district is suitable for its cultivation under unirrigated conditions.

Rajasthan:

Nigerseed cultivation in Rajasthan is restricted to the southern part consisting of Udaipur, Chittorgarh, Durgarpur, Banswara districts. The crop is grown only on hill slopes and marginal lands, with patches of other crops grown. With the availability of early, high yielding suitable variety the area of niger in these districts can be increased with the demonstration of profitability of this crop in waste and barren lands.

Gujarat, Uttar Pradesh and North eastern Hill regions:

The area under this crop can be increased in these states. In Gujarat, Waghi Dang is a very potential area where this crop is already being grown to certain extent. Similarly, in hilly areas of Uttar Pradesh, particularly Mirzapur district, and in Bundelkhand region, there is large area where this crop is being grown and can be expanded. In North-eastern states, the crop is gaining importance as in hill areas of West Bengal.

The crop has a great scope as intercrop in crops like sunflower where the pollination requirements of the latter are also met and an additional crop of niger is obtained. Such experiments have given very encouraging results.

Thus, niger has a large scope for expansion in both new and traditional areas.

NEW POTENTIAL AREAS OF NIGER IN INDIA

S.M.Sharma

Niger, although a minor oilseed crop in the world and national economy, is of considerable importance for rainfed conditions on poor soils of course texture, especially on hill slopes, with very shallow soils. The premitive method of cultivation and the lack of attempt on the part of the farmers is based upon several socio-economic factors e.g., ignorance, poverty, lack of credit, inputs and market facilities etc. In spite of these and several other constraints, farmers cultivate niger on account of its low investments and its suitability for lands which are otherwise not suitable for other remunerative crops during the receding Monsoon.

Current researches on this crop provide definite indication that: 1) use of improved seeds increases the yield up to 700-800 kg/ha; 2) good soil depth and soil texture increase the yield substantially, 3) good land preparation, making the land weed free by line sowing followed by thinning and weeding (once or twice) are very useful for increasing the yield; 4) there is substantial increase in yield by application of small dose of nitrogen (about 20 kg/ha) with phosphate fertilizer as basal dose; 5) the crop is not menaced by many insect pests and diseases (except a few including dodder); 6) There is a wide range of sowing period well before the cessation of Monsoon suitable for good yield of this crop making its cultivation profitable under varied situations and 7) the crop may be harvested in time to avoid harvest losses.

Thus it is possible to increase the yield of this crop tremendously with the already available genotype and agro-techniques:

(a) Niger is one of the rare crops with a deep tap root system and with high degree of drought tolerance.

(b) Fertility: In most of the areas niger is grown on hill eroded soils without application of manure or fertilizer.

(c) Weeds: The crop is generally sown as broadcast with the result that weeding of the crop becomes difficult and inter cultural operations are not possible.

The Production and productivity of niger can be improved in the following ways:

1. High yielding varieties and composites/synthetics to suit the different niger growing areas of the country should be evolved. This can be done by breeding for efficient plant type with better harvest index. The varieties evolved so far in the country are selections from the local material. They have very narrow genetic base. To overcome the situation, intensive hybridization program should be taken up.

Germplasm from the farmers of the tribal areas should be collected extensively and thoroughly studied. Germplasm from outside the country, particularly Ethiopia, should be collected where the variability is greater and types of longer duration but higher yield potential are available.

Population improvement should be carried on with recurrent selection.

Niger is a cross pollinated plant due to the self-incompatibility system existing in it. Therefore, selfing produces no seed setting. However, it would be desirable if some self-compatible lines are isolated from the germplasm collection.

2. With the adoption of the production technology already available, tremendous increase in yield is possible. It has been observed that, by adoption of improved practices, 140% increase in yield is achieved. Fertilizer and improved variety are the two major constituents of improved production technology which individually can improve the yield to the extent of 68% and 51%, respectively. Line sowing alone, with all other farmer's practices remaining the same, distributes about 30% increase in yield over broadcast method of sowing.

3. The improved variety and production technology should be effectively demonstrated on farmers' field. The niger farmer is generally an inhabitant of isolated places, remains mostly away from the main stream of the urban/semi-urban society and advanced farmers. It is, therefore, essential that for him separate training be organized.

4. Marketing of the produce is not organized and hence the farmer does not get the worth of his produce. He is victimized by the local tradesmen.

5. Constituents of production viz; fertilizers, plant protection chemical etc. may be made available to the farmers on credit or hire basis; the cost to be realized after harvest of the crop.

6. The farmer can get extra profit from the crop by introducing beehive from which honey can be collected and seed setting in niger could be increased due to bee pollination.

Strategies

1. Improved agronomy of the crop for different agro-climatic regions and growing conditions should be worked out and package of practices should be developed.

2. Impact of improved varieties and improved agronomic practices should be demonstrated so that farmers are convinced of getting higher yields.

3. Concentrated efforts should be made in the major niger producing areas of the state. The potential of the crop can thus be explored.

4. The niger farmer is mostly poor and tribal. Therefore, inputs viz; seed, fertilizer, plant protection chemicals etc. should be made available to farmers on credit/hire basis.

5. The farmers are small producers causing thereby marketing problems. The farmers' produce should be procured by organized agency to ensure remunerative price and incentive to farmers.

6. The farmers can get extra profit from their field if bee hives are introduced in the field. Honey bees will also be helpful in increasing the seed setting, the crop being cross pollinated by honey bees.

PRESENT PRODUCTION, RESEARCH AND FUTURE STRATEGY FOR NIGER IN MAHARASHTRA

A.V. Joshi

Abstract

In India the total oilseed area is 19 million hectares with a production of 13 million tons. The estimated demand in 2000 AD. is 26 million tones of oilseeds in India. Niger is mainly grown in India and Ethiopia. Productivity per unit area in India is 265 kg/ha and that of Ethiopia is 334 kg/ha. Maharashtra, during 1987-88 contributes for 1,21,900 hectarage with 26,200 tones of niger seed. It is grown in five zones having varied intensity of rains (500-3000 mm) and varied soil fertility, (hill tops, sub-marginal land, lower to higher fertility in plains). The yield levels are too low. Studies of production practices of the niger farmer reveals constant use of local cultivar, simply broadcasting of seed, no other interculture operation and harvest at maturity. Breeding research was initiated at Pune (1934) Nagpur (1949) and Niphad (1955). The varieties "Niger B", No. 5, and N-12-3 were released respectively, by the stations mentioned above. Generally these varieties have 10-15% more yield over the locals. In 1983, variety IGP-76 "Sahyadri" is released for commercial cultivation. The IGP-72 entry is being tried on farmers adaptive trial. The culture Phule-4,DHL-1,DN-9 are in the chain of coordinated trials in 1988-89.

As an outcome of agronomic research, line sowing at 20 cm row spacing, adopting thinning before 21 days of sowing, attending weeding 20-30 days after sowing, applying 5 tones of FYM and 20 kg N/ha are the recommendations for niger grower. The studies of niger intercropped with Bajra in 1:1 proportion, and with horse gram 2:2 proportion indicated higher monetary returns (1986-87). The future research strategy in the discipline of botany, agronomy & plant protection is discussed.

Oilseeds, occupying about 19 million hectares with an annual production of over 13 million tons, play an important role in the agricultural economy of India. The widening gap between supply and demand of oilseeds in recent years resulted in the import of oils by incurring foreign exchange of Rs. 15 billon. The thrust to increase the domestic oilseed production is receiving due to priority by farmer, researcher and policy maker. The estimated demand for consumption in 2000 A.D. by 100 million Indian population is projected to be 24-26 million tons alarming a two fold increase in the present yield of oilseed. Niger (*Guizotia abyssinica* Cass.) is mainly grown in India and Ethiopia. The area and production of niger in India is more than that in Ethiopia. The productivity per unit area in Ethiopia is 334 kg/ha and it is more than India 265 kg/ha (1981). Niger occupies fifth position in coverage of total oilseeds in India. It contributes 79% and 75% of the area and production of the world.

Area, production and yield of niger in India is given in Table 1. The average yield of the crop is considerably lower than those of major oilseed crops. Niger is prominently grown in the Madhya Pradesh, Orissa, Maharashtra, Karnataka, Bihar and Andhra Pradesh states. The crop is being popular in some pockets of Tamil Nadu, Rajasthan, Arunachal Pradesh. Unfavourable seasonal conditions encountered in many parts of the country resulted in the decrease in area and production in 1986-87. Maharashtra state ranks third in area and fourth in production amongst niger growing states. The productivity in the state is considerably lower than the state averages of Orissa, Bihar and Andhra Pradesh.

Table 1. Niger area, production and yield in India.

	Area '000 ha				Production ('000 tons)				Yield (q/ha)			
State	1970	1980	1983	1986	1970	1980	1983	1986	1970	1980	1983	1986
All India	486.6	598.7	594.9	588.7	127.7	146.1	175.0	132.1	2.61	2.44	2.94	2.24
Maharashtra	81.9	102.0	95.1	87.3	14.0	17.9	20.3	10.8	1.71	1.75	2.13	1.23
Madhya Pradesh	238.6	224.7	219.9	220.8	44.0	32.5	47.6	32.1	1.84	1.45	2.16	1.45
Orissa	77.8	158.1	180.1	171.5	36.3	65.8	81.2	60.5	4.67	4.16	4.50	3.52
Karnataka	24.5	54.8	54.0	53.1	3.4	19.6	9.4	9.3	1.39	1.75	1.74	1.73
Bihar	51.5	47.9	37.4	36.1	22.2	17.7	14.4	13.5	4.28	3.70	3.85	3.73
Andhra Pradesh	13.9	10.6	6.8	13.5	7.8	2.5	2.0	3.7	5.61	2.36	2.99	2.74

Major districts of the state in coverage of niger area are Nasik, Osmanabad, Ratnagiri and Beed. About 60% of the total area of the state under niger falls in the following zones: 1) Ghat Zone: (3000-5000 mm rains), 2) Very high rain fall zone: (2250-3000 mm), 3) Transition "B" Zone: (700-1200 mm) 4) Assured rain fall zone: (700-900 mm) and 5) Scarcity zone: (500-700 mm) with varied altitudes 50-180 m asl.

Current yield of niger per unit area is extremely low and its cultivation is beset with variety of constraints like shattering, self incompatibility, lower priority of its cultivation, non use of high productivity and high intensity of cropping system, non adoption of improved package of practices. To overcome these constraints, it is necessary to survey niger area, socio-economic conditions of the niger grower, package of practices and the cropping system.

Production practices of niger farmer

The cultivation of niger is undertaken by tribal people as their principal means of earning money. Niger is grown for cash income, for home use as cooking, lighting and as a component of high energy diet. Niger is taken up mostly as a sole crop and in some pockets it is intercropped with finger millet, bajra and hill millet. The studies of niger farmer of the Nasik district reveals that they have small holdings (0.4 ha to 13.2 ha) out of which 7-36% is utilized for niger cultivation. Niger-finger millet is a populer rotation. The grower receipts monetary returns of Rs. 600-3000. Regarding the disposal of Niger yields, about 70% of the produce is sold in market, 15% of the seed is used for home consumption. The farmer's just broadcast 5-15 kg/ha seed of local varieties after receipt of monsoon rains on undulating land, on slopes and tops of hills and in plains. It is grown in an adverse condition where other crops may virtually fail. The crop is subjected to various biotic and abiotic factors. No cultural operations are undertaken except sowing by broadcasting and harvest the crop at maturity.

Niger Breeding

Past research

Though niger occupied 17% of total oilseed area of the state, proper attention has not been given in the fields of agronomy, breeding, entomology and pathology. Literature indicates scanty research efforts were made mostly of academic interest. The then Department of Agriculture, Bombay state initiated research in breeding in the decade of 1930. In 1934-35 the varieties niger "A" and "B" gave 10% more yield over local.

The research efforts were concentrated at Nagpur during 1940-50. The variety No. 5 is recommended for hilly areas of Vidharbha. The breeding research executed at Niphad during 1950 helped in releasing, in 1955, N-12-3 a most popular variety of the time giving about 10% more yield over the local.

The operation of All India Co-ordinated Research Project since 1974 onwards geared the program of evolving varieties and formulating of package of practices. The variety "Sahyadri" (IGP-76) is released in 1983. It gives 31% more yield than the local cultivars. It is a national variety and under best management, it yields up to 1100 kg/ha (Table 2).

Table 2. Niger varieties released for the Maharashtra state.

Variety	Year of release	Station of release	Yield Kg/ha	Oil %	Days to maturity	Area for which released	Salient features
No. 5	1934	Nagpur	200	38	105	Vidharbha	Seeds are black and small. Sensitive to thermo-photo period.
Niger-B	1949	Pune	220	39	110	Bombay State	Medium in duration.
N-12-3	1955	Niphad	250	40	115	Bombay State	Insensitive to photo-thermo period.
Sahyadri (IGP-76)	1983	Dhule	300	40	120	Western Maharas-htra and Konkan	Widely adapted in the states of Maharashtra, Orissa, West Bengal and Dadra Nagar Haveli. Seeds
region	are small and blackish in						colour.

Present research

Breeding efforts are concentrated for evolving varieties. Proven viable technology generated for increasing the per hectare yield under different agro-ecological and crop growing situations. Systematic research approach is formulated by adopting a chain of experimentation: 1) Collection, maintenance and evolution of germplasm. 2) Population improvement program. 3) Hybridization program. 4) Preliminary yield trial. 5) Trial of promising strain. 6) Multi-location varietal trial. 7) All India co-ordinated varietal trials (initial evaluation trial, and coordinated varietal trial I and II, in late and early groups).

At present IGP-72 culture is under evaluation on farmers' field under Adaptive/Minikit program. The strain Phule-4 is in apex testing under CVT-II. The entry DHL-1 is under the screening test at CVT-I. The entry DN-9 and DN-4 developed by the centre is included in the Initial Evaluation Trial (1987-88).

There is a great scope to study genetic variability available in indigenous/exotic cultures, genetics of self-incompatibility, development of inbreds for composite/synthetics, development of specific, special production technology capable of producing immediate tangible results for achieving national targets of increased oilseed production by transforming the available production technology generated.

Research on Agronomy

Very little attention has been given to the research on agronomic aspects prior to the establishment of a coordinated research project. The following are the recommendations released for the farmers:

1) line sowing at 20 cm distance between rows in heavy rainfall zone,

2) one thinning before 21 days of sowing to maintain plant-to-plant distance of 10 cm,

3) weeding once 20-30 days after sowing,

4) sowing upto the first fortnight of August in heavy rainfall zone,

5) application of 20 kg N/ha,

6) application of 5 tones of FYM,

7) intercropping of niger with bajra (1:1) and horse gram (2:2) have given higher monetary returns (1987-87), and

8) in the order of importance of improved package of practices, the use of improved variety, plant protection, fertilizer and line sowing were found to be effective in niger cultivation.

Research information is yet to be worked out for cropping system, cropping sequence, relay cropping, studies on impact of improved package of practices on farmer's field.

Future Research Strategy

Low productivity and high instability are the main barriers of niger yields. The information on genetics, restructuring of plant architecture towards imparting maximum photosynthetic efficiency to improve sink capacity has to be worked out.

A) Breeding

i) Collection evaluation, conservation of indigenous and exotic germplasm for yield, oil content and quality and adaptability.

ii) Breeding for seed yield, fertilizer responsiveness, non-shattering, high harvest index and desirable maturity.

iii) Study of genetic variability, information on genetic control and efficient screening method for development of population for breeding varieties by composite/synthetic.

iv) Hybridization program to incorporate photo-thermo insensitiveness and disease and pest resistance.

v) Estimation of genetic parameters of yield and yield contributing characters.

vi) Convergent Improvement Program for ideotype suitable for situation asked.

vii) Population improvement Program for improving yield.

viii) Yield trials of promising genotypes, and

ix) Production of pure and quality seed.

B) Agronomy

1) Greater priority for low input low cost technology.

2) Adoption of seeding time and rate for specific situation.

3) Working out fertilizer/plant population requirements of improved varieties.

4) Studies of the existing cropping system, soil erosion, weed control, fertilizer use and strip cropping.

5) Determination of components of yield.

6) Development of cultural practices for higher yield.

7) Demonstration of improved package of practices.

8) Studies of socio-economic constraints of marginal, sub-marginal and trial farmer's.

C) Plant protection

1) Assessment of yield losses due to pest/diseases.

2) Survey of pests/diseases of niger and

3) Research to generate effective pest management practices.

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NIGER IN TRIBAL BIHAR

H.B.P. Trivedi

Tribal Bihar with a geographical area of 79710 km^2, comprises plateau, sub-plateau and foot-hills of south Bihar. The area is administratively known as Chotanagpur and Senthal Parganas. This region is largely inhibited by schedule tribes, schedule castes and other rural communities who have adapted tribal way of life. They account for about 60% of the total population. More than 70% of the farmers belong to the poor socio-economic group and are small and marginal farmers.

The climate of this region, in general, is sub-humid megathermal with large winter water deficiency. The variation in the total amount of rainfall is very high (900 mm to 1500 mm), the average for the last 30 years is about 1350 mm. About 90% of the total precipitation takes place during kharif season i.e., June to September and the rest received during winter. Even during kharif season, drought spells of 4 to 6 weeks duration are not uncommon. Rainfall is not evenly distributed throughout the season and sharp peaks have been observed in Monsoon months.

The agro-climatic conditions prevailing in this tribal belt and the socio-economic status of the farmers are best suited for pulses and oilseeds cultivation. Among oilseeds, niger *(Guizotia abyssinica* Cass.) possesses unique characteristics to withstand heavy downpour as well as moisture stress and can very well establish in pebbled, shallow, poor soil which is prevalent in uplands of this region where it is commonly grown, where nothing else can be grown and can easily be seen from valleys to hill tops. This crop has least disease and pest problems.

Status of niger

India is one of the principal niger growing countries where it is grown in 5.8 lakh hectares with annual production of 1.53 lakh tons. Bihar state ranks fourth in national scenario in acreage and also in production, its share being 9.79 and 10.08 %, respectively in acreage and production of the nation, Table 1.

Table 1. Area, productiom and productivity of niger in India.

States	Area		Production		Productivity
	('000 ha)	(%)	('000 tons)	(%)	(kg/ha)
Madhya Pradesh	224.9	38.47	40.8	28.75	181
Orissa	137.2	23.47	57.6	30.77	420
Maharashta	101.0	17.27	24.1	18.80	239
Bihar	56.9	9.79	16.9	10.08	269
Kernataka	53.7	9.18	9.3	8.09	173
Andhra Pradesh	10.3	1.06	3.6	2.40	350
Dadar & Nagar Haveli	0.6	-	0.2	-	257
All India	584.6		152.5		266

Source: Agricultural situation in India, Oct. 1982.

In Bihar almost all the oilseed crops are grown viz., rapeseed and mustard (82,000 ha), linseed (85,200 ha), niger (56,900 ha) sesame (19,400 ha), groundnut (5,100 ha) and other oilseed in

2,100 ha. The total area under oilseed is 251,000 ha. Niger ranks third among oilseed crops, but among the kharif oilseed crops it ranks as No. 1 in Bihar state.

In Bihar, niger cultivation is totally confined to Chotanagpur and Santhal Paraganas. In this tribal region 57% of the total area under oilseed crops is occupied by niger. At the production front, 10.20 thousand tons is contributed by niger out of the total of 24.12 thousand tons of all oilseed production of the region. In other words, niger crop alone shares 42.47% of the total oilseed production (Table 2).

Table 2. Area and production of various oilseed crops in Chotanagpur and Santha Paraganas

Crops	Area ('000 ha)	Area (%)	Production ('000 tons)	Production (%)
Linseed	12.10	12.16	4.10	17.07
Rapeseed & Mustard	16.00	16.07	4.70	19.07
Sesame	12.20	12.26	2.34	9.74
Niger	56.90	57.17	10.20	42.47
Groundnut	2.33	2.34	2.68	11.15
Total	99.53		24.02	

Source: National Agril. Research Project, 1982.

Niger is seeded as a late kharif oilseed crop under rainfed condition in poor shallow, pebbled and low water retentive soil of the uplands. It is also grown as a second crop in the lands vacated after the harvest of Gundli (*Panicum miliare*), Ragi and Gora paddy. Sometimes, it is also seeded mixed with Ragi, Urd and Gora paddy. In few districts, it is grown as border crop around Urd, Moong and Ragi crops, to deter the animals for grazing. This crop is mostly grown without any fertilizer application and proper crop management.

Crop improvement work

With the creation of Regional Agricultural Research Institute at Kanke, Govt. of Bihar had sanctioned a scheme for the improvement of various oilseed crops. While researches on other oilseed crops were started, niger could not get its proper place until mid sixties, when niger research could get its importance. Variety Ootacamund which matures in 120 days and produces 400 kg/ha has emerged as the most promising one among many entries tested for many years. This variety has been suggested for cultivation in place of local varieties in plateau region of Bihar.

Later on, Indian Council of Agricultural Research sanctioned a scheme on "Improvement of oilseed (niger)" in 5-years plan to give a major thrust for the improvement of this native oilseed crop of the region. Since then, concerted efforts are being made for the varietal improvement and crop management.

N-5, a variety from M.P. was identified as promising one over Ootacamund in maturity and in yield potential. N-5 matures in 95 to 100 days with yielding ability of 400-500 kg/ha. It has 40% oil in the seeds. Consequently, N-5 was recommended to farmers as an improved variety to replace Ootacamund. From then onwards, this variety is serving the interest of niger farmers for sowing as sole or second crop after the harvest of Ragi and Gora paddy.

More than 175 germplasm lines are being maintained by sibbing and are also being evaluated for various agronomic characters and yield components. Selected lines are being utilized for channelizing the desired genes in one gene pool. Correlation studies have revealed that selection based on number of capitulum per plant, plant height and number of secondary branches, independently or jointly may be effective in increasing seed yield in niger. Divergence study revealed that the characters such as 1000-seed weight, days to maturity, capitulum diameter, plant height and yield per plant were the potential factors which contributed a lot towards divergence among the niger germplasm. Comp-2-3-4, KIC-24, KIC-27 and No. 71 were recognized as the potential parents, for exploitation of heterosis for seed yield.

A large number of single plants were selected on the basis of their phenotypic behavior from 13 elite populations. These selections were evaluated for several years for yield potential out of which seven progenies have been identified as outstanding. Three of them viz., N-5-2 (BNS-1), GA-11-1 (BNS-2) and GA-5-1 (BNS-3) have been entered in various AICORPO trials for multilocational evaluations.

Eighteen composites have been developed by utilizing germplasm lines which were early, late and superior in yield contributing characters. These bulks were evaluated for several years for their yield potential in replicated trials. Evaluation studies revealed the superiority of KEC-1, KEC-2, KEC-3, KEC-5, KEC-7, KEC-11 and BNC-120 over the local check. Five of them are being further evaluated in AICORPO trials.

Evaluation of a large number of varieties developed at other coordinating centres and at this centre in AICORPO trials and station trials revealed the superiority of the following varieties over the local and national checks.
These are listed below centerwise:

Kanke: BNC-120, KEC-1, and BNS-1
Maharastra : IGP-72
Karnataka : No.71, RCR-290 & RCR-18
Orissa : GA-1, GA-5 and GA-10
M.P. : N-5, N-35 and CHH-1.

Out of these high yielding varieties: N-5, KEC-1, BNS-1, CHH-1, No. 71 were identified as early whereas BNS-120, RCR-290, RCR-18, GA-1, GA-5 and GA-10 were found late in maturity.

Identification and Utilization of Male-Sterility

Male-sterility, in niger was, for the first time observed and identified, crop at Birsa Agricultural University. It was genetic male-sterility and found to be governed by recessive alleles. All bisexual tubular disc florets were modified into pistillate florets. Male-sterility is gyno-monoeceous. Though phenotypic marker for male sterility could not be identified in vegetative stage, the male-sterile plants could be pinpointed by their large sized buds. Identification of male-sterility has made possible for the large scale production of hybrids in this crop. Various types of hybrid lines have been produced at this centre with the male-sterile line. Evaluation of these hybrids unveiled that top-crossed hybrid (BNH-1) was superior in yield and yielded 7.2% more seeds than sibbed hybrid (BNH-2). Hybrid BNH-3 exhibited 20% heterosis over its male parent (BNC-120) in yield.

Crop-production

Experiments on crop-production have revealed that optimum time of sowing niger in Bihar plateau is between 15th and 30th of August. Plant population should be maintained at 250,000 to 300,000 ha for obtaining maximum seed yield. A distance of 30 cm from row-to-row and 12-15 cm from plant-to-plant is found suitable, when niger is grown in normal time, but when it is grown late i.e., in September, rows should be spaced narrower (25 cm) and plant-to-plant distance should be reduced to 10 cm.

To obtain an adequate plant stand, seed rate of 5-6 kg/ha is needed for normal sowing time and 7-8 kg/ha for late sown crop. Fertilizer dose of $N_{20} P_{20} K_{10}$ kg/ha is found remunerative, however, response of N_{40} kg/ha has also been found. In crop sequence experiment, highest seed yield of niger is obtained from moong followed by niger. Intercropping results indicate that black gram, and ragi intercropped with niger (1:1) is more profitable than growing niger alone during kharif, whereas growing 3 rows of niger between paired rows of red gram is found to be more remunerative than other intercropping, Table 3.

Table 3. Effect of intercropping of niger with pulses on grain yield and niger equivalent yield (kg/ha).

Treatments	Yield (kg/ha) Niger	Yield (kg/ha) Intercrop	Niger equivalent yield	Land equivalent ratio
Niger sole	262.4	-	342.9	1.00
Soybean sole	-	685.7	1496.1	1.00
Urid sole	-	1068.7	1763.9	1.00
Arhar sole	-	1102.4	758.2	1.00
Cowpea sole	-	1083.2	436.2	1.00
Moong sole	-	316.6	362.4	1.00
Soybean + Niger 1:1	285.5	302.5	441.8	1.23
Soybean + Niger 2:2	203.5	377.1	392.1	1.11
Urid + Niger 1:1	184.3	419.9	772.1	0.91
Urid + Niger 2:2	270.6	471.2	930.3	1.21
Arhar + Niger 1:1	257.0	752.1	1460.5	1.41
Arhar + Niger 2:3	392.2	630.5	1401.0	1.67
Cowpea + Niger 1:1	236.6	547.2	619.6	1.18
Cowpea + Niger 2:2	198.4	498.0	547.0	1.05
Moong + Niger 1:1	219.4	160.8	444.5	1.14
Moong + Niger 2:2	255.0	137.4	447.3	1.17
S.Em +			96.66	0.10
C.D. 5%			262.40	0.28
C.V. %			20.80	15.32

CULTIVATION AND VARIETAL IMPROVEMENT OF LINSEED IN INDIA

R.N. Dubey

Linseed is an important oilseed crop on account of its drying oil which is an unparallel source of paints and varnish industries. The Linseed *(Linum usitatissimum)* displays great diversity in morphological and biochemical characteristics. The varieties of the same species, when cultivated for their seed, are called oil flax, seed flax or linseed and when grown for their fibre are known as flax. The seed flax or linseed varieties are dwarf, profusely branched having good seed yielding potentialities. Such type of varieties are under cultivation in warmer regions of the world viz., Argentina, Canada, India, part of the USSR and USA, etc. The fibre flax varieties are tall, scarcely branched having low yielding ability. This group of varieties is under commercial cultivation in the more temperate regions throughout the Northern hemisphere. In India, linseed is cultivated exclusively for seed. With an area of about 1.45 million hectares and 0.44 million tones production, India presently ranks first in acreage followed by USSR, Argentina, Canada and USA and third in production after Argentina and Canada on world map of linseed cultivation. Though India shares about 30% of the world acreage, the country contributes only 17% of the total world production because of its low productivity i.e., 299 kg/ha as against the average yield of 960 kg/ha of Canada, 913 kg/ha of Argentina, 819 kg/ha of USA and 552 kg/ha of the world. On acreage basis, the leading linseed growing states in this country, in their order of merit, are Madhya Pradesh, Uttar Pradesh, Maharashtra, Bihar and Rajasthan which together account for about 8.8% of the total linseed area and production. The low productivity of the major linseed growing states forms the basis of the low national average yield.

Constraints to productivity

Linseed is rated as the second grade oilseed crop by the Indian farmer and is, therefore, religated to the marginal and sub-marginal lands under moisture stress condition using traditional low yielding varieties with low or no inputs resulting in low seed yield. Besides the prevailing practices of mixed cropping and intercropping, adoption of ages old Paira or Utera system of linseed cultivation in about 25% of the total area with an average yield of 1.0 q/ha is the single major factor to lower down the average productivity to a great extent. Though this is one of the best known dry land practices of utilizing residual paddy soil moisture when tillage is difficult, but due to compact soil structure which restricts root and shoot growth, high mortality of seedlings particularly at harvesting of paddy, complete lack of tillage and fertilizer use, substantial sharing of residual crop nutrients and soil moisture by weeds, very poor yields are recorded.

The traditional varieties, apart from their poor response to increased inputs in the form of fertilizer and irrigation, are prone to diseases and pests. Rust, wilt, powdery mildew and Alternaria blight among the diseases and linseed bud fly *(Dasyneura lini)* among the pests are the serious problems with varying intensity of infection and losses in different regions. Monitoring of the diseases and pests during the last few years by the AICORPO scientists have revealed the dimensions of these problems in different regions. In north west region i.e., Jammu & Kashmir, Himachal Pradesh, Haryana, Punjab, and U.P. Hills, rust, powdery mildew, wilt and Alternaria blight have been the serious problem and merit in that order. Entire Gangetic alluvium of Uttar Pradesh, Bihar, West Benal including Assam have also the major problem of rust followed by Alternaria blight, powdery mildew and wilt. In Peninsular region and southern plateau comprising Bundelkhand region of Uttar Pradesh, Madhya Pradesh, Orissa, Karnataka, Maharashtra and Rajasthan, powdery mildew, wilt, rust and linseed bud fly cause losses to linseed crop. However, with the availability of the rust, powdery mildew and wilt resistant/tolerant varieties developed by the AICORPO centers, Alternaria blight and linseed bud fly are the only left serious problem to overcome.

Linseed breeding and varietal improvement

Linseed breeding was initiated in India in 1915 at the Imperial Agricultural Research Institute, Pusa, Bihar (now Indian Agricultural Research Institute, New Delhi). Later on, some state departments of agriculture and institutes at Kanpur, Indore, Pune, Bernampore, Kangrha, etc., also started improving linseed varieties for their situations. The research work was strengthened in 1947 by the Indian Central Oilseed Committee (ICOC) by way of sponsoring adhoc schemes to the state departments of agriculture and institutes. In view of the limited impact of ICOC schemes on linseed productions, Indian Council of Agricultural Research started All India Co-ordinated Research Project on Oilseeds (AICORPO) in 1967 with linseed as part of it having interdisciplinary approach, free exchange of breeding material, information and ideas, planning of technical programs and research methods in annual workshop meetings. The intensified work under AICORPO aimed at developing disease resistant, early maturing, high seed and oil yielding varieties and their production technologies for maximum production. Consequently, the concerted efforts of some centers particularly kanpur, Raipur, Jabalpur and Kangrha resulted in the development of as much as 19 varieties for different systems and situation including 9 mono/multiple disease resistant/tolerant varieties: namely, Pusa-2, Pusa-3, Himalini, Jawahar-23, Garima, Shubhra, Sweta, Laxmi-27 and Kiran released in 1985 and onward. All these varieties have a yielding ability of 8-10 q/ha under rainfed and 15-20 q/ha under irrigated situation. Some varieties such as Neelum, K-2, Jawahar-23, and Garima yielded 25-30 q/ha under ideal management.

Double purpose linseed

It is well known that linseed fibre is one of the oldest vegetable fibre to be spun and woven. In characteristics, it has been reported to be lustrous, stronger, less stretchy, more durable and better resistant to environmental fluctuations. The flax fibre has been highly regarded and rated indispensable particularly during war periods. In order to develop dual purpose varieties for high seed and fibre production, the efforts were made about 50 years back but unfortunately the matter could not be persuade in right perspective in the subsequent decades and the country is paying cost under the umbrella of a very heavy import. However, very recently, two double purpose varieties namely, Gaurav and Jeevan have been developed and released in 1987 for commercial cultivation.

In agronomic trials, Gaurav has yielded more than 22 q/ha seed and 14 q/ha fibre. Both these varieties will go a long way in maximizing the linseed production as it has been proved time and again that improved varieties of linseed respond well to inputs and enherit high yield potentials. The salient features of the varieties released from time to time for commercial cultivation are given in Table 1 while the region-wise varietal recommendation is given below:

1. North west region: K2, LC-185, Himalini, Pusa-2, Pusa-3, LC-54, and Jeevan.

2. Gangetic alluvial region: Mukta, Noelum, T397, Neela, Garima, Sweta, Shubhra, Gaurav, and Jeevan.

3. Peninsular region; and southern plateau: Hira, Laxmi-27, T-397, Jawahar-1, Jawahar-7, Jawahar-17, Jawahar-552, Jawahar-23, C429, S-36 Chambal, Pusa-2 and Kiran.

Present activities for linseed improvement

Under Seventh Plan, the linseed improvement work has been strengthened by increasing the number of AICORPO centres considering the state-wise linseed cultivation, problems and existing AICORPO facilities. Some of the existing centres have been raised to the status of main centres providing the infrastructure for multidisciplinary approach while the others are to work as subcentre or joint centre with the provided staff under linseed and other crops at the centre under AICORPO.

With the technology mission on oilseeds in operation, the research work has been further intensified at some selected AICORPO centres on problem oriented activities assigned to them. The progress of work on such activities is regularly monitored. The centres are doing their best to achieve the time bound mandate assigned to them. These activities are listed below alongwith the centers working on them.

Research activity	Centres
1. Double purpose variety	Kanpur Kangrha
2. Alternaria resistance	Kanpur, Faizabad, Raipur, Mauranipur, Kangrha, Kanke, Akola
3. Budfly resistance	Kanpur, Mauranipur, Raipur, Akola
4. Wilt resistance	Kaipur
5. High yielding varieties (rainfed and irrigated conditions)	Faizabad, Kangrha
6. Short duration varieties	Mauranipur, Raipur, (Central and peninsular Akola, Kota, Raichur region)
7. Germplasm unit	Kanpur

Breeder seed production

The breeder seed of the improved varieties is produced under the direct supervision of the breeder to supply the multiplying agencies in order to make continued flow of quality seed to the farmer after multiplication in subsequent stages. Recently, a centrally sponsored scheme on production of breeder seed of annual oilseed crops started functioning since September 1988 with its seed producing centres and monitoring systematically the production and supply of the quality seed.

Linseed improvement work at C.S.A. University of Agriculture and Technology, Kanpur

Breeding: Aiming at developing rust resistant high yielding varieties of linseed initiated in 1023 resulted in the recommendation of T.1 and T.477 for Bundelkhand and alluvial tracts, respectively, of Uttar Pradesh in the fourties.

Table 1. Salient features of recommended varieties.

Variety	Duration (days)	Ave. yield (kg/ha)	Oil content	Suitability	Assistance
K.2	170.175	1100	46	Irrigated	Rust, Wilt
C.429	120-125	500	44	Rainfed	-
S.36	105-110	400	37	Rainfed/Inter-cropping	Wilt
T.397	120-125	1100	44	Rainfed; widely adoptable	Rust, Wilt, Drought
Hira	130-135	1200	43	Irrigated/rainfed	Rust, drought
Mukta	125-130	1200	45	Rainfed/irrigated	Rust, Wild
Neelum	135-140	1500	43	Irrigate/high fertility	Rust, Wilt
LC.185	165-170	500	46	Utera	Rust, Wilt
Himalini	155-170	1300	42	Rainfed/irrig. Utera	Rust, Wilt
LC. 54	155-170	1300	42	Irrigated	Rust
Jawahar-1	115-120	900	44	Rainfed/irrigated	Escapes linseed budfly,
Jawahar-7	115-118	300 Utera 300 R.f	43	Utera	Rust
Jawahar-17	115-120	800 R.f 1300 Irr.	43	Rainfed/irrigated	Rust
Jawhar-552	115-120	900	44	Raifed/irrigated Utera	Rust, wilt, powdery mildew
Naela	125-130	850	40	Rainfed	wilt
Cnambal	115-120	900	44	Rainfed/irrigated	-
Jawhar-23	115-120	1000	43	High fertility	wilt, Powdery mildew
Pusa-2	140-145	730 R.f 1300 Irr.	43	Rainfed/irrigated widely adoptable	-
Pusa-3	140-150	1350	42	High fertility	-
Garima	125-130	1500	42	Irrigated/high fertility/delayed sowing	Rust; tolerant to powdery mildew, wilt, Alternaria blight.
Shubhra	130-135	1400 Irr. 870 R.f	45	Irrigate/rainfed; excellent oil quality	Rust; Tolerant to wilt and Alternaria blight.
Sweta	130-135	880 R.f	44	Rainfed	Rust, powdery mildew; Tolerant to Alternaria blight.
Laxmi-27	110-115	1020 R.f	45	Rainfed/irrigated	Rust, wilt, powdery mildew.
Kiran	120-125	750 R.f	43	Rainfed	Rust, wilt, powdery mildew, Alternaira blight.
Double purpose varieties					
Gaurav	135-140	1050-Seed	43	Irrigated best suited to Gangetic alluvium	Rust, tolerant to powdery mildew and Alternaria blight
Jeevan	175-180	1090-Seed 1000-Fibre	46	Irrigated; best suited to North-west region	Rust, Wilt, Powdery mildew

On the inception of ICOC scheme, the intensified breeding work led to the release of T.126 in 1958 to replace T.477 and T.603 alongwith T.397 in 1960 to replace T.1. In 1964, three more rust and wilt resistant varieties, namely, Hira for Bundelkhand, Mukta for eastern and Neelum for central western part of Uttar Pradesh were released for commercial cultivation. Among these, T.397 and Neelum are still doing well in fields. T.397 has also been adopted by Bihar, Assam, Madhya pradesh and Rajsthan states. It is also being used as national check in AICORPO trials since 1976. On the inception of AICORPO in 1967, the research work was further intensified. The breeding work on resistance against rust, powdery mildew and wilt taken up in mid-seventies and on *Alternaria* blight in early eighties has resulted in the isolation of a large number of genotypes almost free from rust, and powdery mildew. Several promising genotypes tolerant to *Alternaria* blight and wilt were also developed. The varietal testing in early eighties resulted in the release of four seed varieties, namely: Garima, Shubhra, Sweta and Laxmi-27 and one double purpose variety i.e. Gaurav. Among these, Garima for irrigated, Sweta for rainfed, Shubhra for both the situations having excellent oil quality alongwith the double purpose variety. Gaurav has been recommended for Gangeticlluvial region of U.P. Bihar, West Bengal including Assam while Laxmi-27 has been recommended for Bundelkhand region of Uttar Pradesh. All these varieties have the yield potential of 20-25 q/ha under irrigated and 12-15 q/ha under rainfed situations with an oil content of 43-45%. The double purpose variety Gaurav has yielded more than 22 and 14 q/ha seed and fibre, respectively, in agronomic trials.

Breeder seed production: Under this program about 150q breeder seed was produced and supplied to the seed multiplying agencies for further multiplication in subsequent stages in order to make available the quality seed to the farmers.

Agronomy: Under this discipline, the agronomic requirements of the varieties released, from time to time, were standardized, perfected and recommended. The experiments conducted with latest identified/released varieties on fertilizer and irrigation requirement, sowing time, spacing, seed rate, etc. for seed and double purpose varieties resulted in the recommendation of sowing of improved varieties in second fortnight of October with 30 kg/ha seed rate in rows, 25 cm, apart at 80:40 kg and 40:20 kg/ha N = P_2O_5/ha under irrigated and rainfed conditions, respectively. In Budelkhand region, the optimum sowing time has been found to be the first fortnight of October and 30 cm row distance due to the specific soil structure. The fibre yield in double purpose varieties is increased with the increase in seed rate (45 kg/ha) with closer row spacing (20 cm). Intercropping of linseed with gram or lentil in row ratios of 1:3 to 3:1 and with potato adjusting its three rows in place of the fourth row of potato appeared more remunerative than sole cropping. Linseed gave the lowest cost benefit ratio of 1:2.51 as compared with other oilseeds and cereals viz., mustard (1:1.95), toria (1:1.76), safflower (1:0.55), sunflower (1:0.13), castor (1:0.59), wheat (1:0.59) and barley (1:0.22).

Plant protection: Rust, *Alternaria* blight, powdery mildew and wilt in diseases and bud fly in pests have been the major problems of this region. The natural sources for resistance to rust, powdery mildew and wilt have been identified and transferred to improved varieties.

Most of the varieties released from this institute are resistant/ tolerant to rust, wilt and powdery mildew. In screening, the cultures with E.C. Nos. 544, 15818, 1387, 19288, 41520, 41549, 41618, 41667, 41739, 41797, 158993, Fx165, KL169 and Chharpuran have been found to be resistant to *Alternaria* blight. Their resistance is being incorporated in the improved varieties. The screening of natural source of bud fly is in progress. However, the escaping varieties have been developed. The economic chemical control measures for the diseases and pests have been worked out and recommended accordingly.

AGRONOMIC MANAGEMENT/ AGRO-TECHNIQUES FOR IMPROVING PRODUCTION OF NIGER AND LINSEED

G.L. Mishra

India is one of the major oilseed growing countries of the world. Oilseeds occupy about 10% (20 million ha) of the gross cropped area. Groundnut, rapeseed and mustard, linseed, sesame and castor are the five major oilseeds. Besides, soybean, niger, sunflower, safflower etc. are also gaining importance. However, the total production of edible oils in the country fall too short of the demand. Therefore, to bridge this wide gap and to meet the minimum requirement of 6.5 kg per capita per annum of fat against 11 kg of world average and 22 kg of developed countries, a large quantity (about 1.5 million tons) of edible oil is being imported and an enormous amount of valuable foreign exchange (about Rs. 15 billions) is being spent annually.

To meet this challenge a series of research and extension projects located in different agro-ecological zones, throughout the country are undertaking intensive measures so as to generate technically feasible and economically viable production technology for different category of farmers (as no-input, low input and high input technology). Against a target of 18 million tones of oil seed by the year 1990, a production of 16 million is expected this year with the result that the import bill is likely to be reduced considerably.

Niger

In the world, India occupies the first position in area as well as production. The area, production and productivity of niger in India is about 0.6 million ha, 0.15 million tons and 250 kg/ha, respectively. Among Indian states, Madhya Pradesh ranks first in area followed by Orissa and Maharashtra and these together account for about 80% of the area and about 85% of the production of Niger in the country. The area, production and productivity of niger in M.P. is about 0.22 million ha, 40,000 tons, and 183 kg/ha, respectively. The important niger growing districts in the state are Chhindwara (41000), Mandla (33000), Darguja (27000), Raigarh (23000), Shahdol (18000), Seoni (18000) Basatr (17000), Betul (14000), and Guna (11000), which together occupy about 90% of the area and production.

Though niger is a minor crop on the oilseed map of India contributing about 3.5% of the area and about 1.3% production of oilseeds in the country, it is a major oilseed crop of the tribal population for whose uplift all out efforts are being made at national level.

Besides, the crop has some special features in its favour:

i) It grows on a very poor, gravelly and undulating soil in hill forest areas where most of the crops may not survive.

ii) It is comparatively free from pest and diseases.

iii) Unlike groundnut, sesame, sunflower etc, niger is free from any antinutritional/toxic constituents.

Realizing this importance, the crop was included under "All

India Coordinated Research project on Oilseeds" and now the research work is carried at five main research stations of the important niger growing states in the country viz. Chhindwar (M.P.) Dindori (MS) Similiguda (Orisa), Kanke (Bihar) and Raichur (Karnatka) and at a few voluntary centres.

The salient features of the work being carried out in the institution (JNKVV) at Chhindwara (main centre) and at Tikamgarh (voluntary centre) are as follows:

i) Ootacamund is the popular variety in the state with 110 days duration, 42% oil and yield potential of about 5 t/ha. Chhindwara centre has developed varieties like CHH-1 and CHH-2. These improved varieties gave significantly higher yield over the farmers' local variety.

ii) A week or fortnight after the onset of Monsoon has been found the optimum time of sowing for the crop.

iii) In an intercropping trial (niger + red gram (2:2) gave highest return of Rs. 4256. followed by niger + moong 2:1) Rs. 3200 niger + urid (2:2) Rs. 3161 and niger + soybean (1:1) Rs. 1638 against Rs. 126 - under pure niger.

While at Tikamgarh niger + sesame, niger + groundnut and niger + soybean gave a monetary return of Rs. 3295, 1767, & 1604/ha respectively, against Rs. 963 under pure niger.

iv) At Chhindra full package of practices (441 kg/ha) increased the niger yield by about 100% over the local practices (216 kg/ha).

v) Besides, intercropping niger with pulsesviz., *Phaseolus* spp, and *Cajanus cajan* also proved highly remunerative than pure niger.

vi) The application of different constituents of production technology viz., improved variety, fertilizer or plant protection increased yield by about 50% while the full package of practices increased yield by about 100% over the farmers' practice.

The reader is requested to refer to tables 1-7 for niger.

Linseed

India has the largest acreage of linseed in the world. It is one of the five major oilseeds of the country. The area, production and productivity of linseed in the country is about 1.5 million ha, 0.5 m.t. and about 250 kg/ha, respectively. In India, Madhya Pradesh ranks first in acreage followed by U.P., Bihar, Maharashtra etc. The area, production and productivity of linseed in Madhya Pradesh is about 0.56 m.ha, 0.10 m.t. and 200 kg/ha respectively.

It is distributed throughout the state under different agro-ecological conditions of the 45 districts in the state. Twenty districts have more than 10,000 ha each while other 8 districts have between 5 & 10 thousand acres under linseed.

The crop yields about 35 to 45% oil which is mostly (about 80%) used for industrial purposes like paints varnish, etc. Besides, the crop also yields good quality fibre which is used for a number of products like canvas, twines,

Table 1. The effect of date of sowing on the seed yield of niger (Chhindwara 1981, 1982, 1983)

Treatment	Seed yield (kg/ha)
Onset of monsoon	311
10 days later	317
20 days later	262
30 days later	215
40 days later	165

Table 2. The effect of improved varieties on the yield of niger (Chhindwara 1982, 1983, 1984)

Treatment	Seed yield (kg/ha)
Local variety	216
Improved variety	328

Table 3. Effect of plant population and nitrogen levels on the seed yield of promising varieties of niger (IGP-76 and Ootacamund)

Treatment	Seed yield (kg/ha)
1) Plant population/ha	
30 X 15 (Approx.200,000)	266
30 X 10 (---"-- 300,000)	272
30 X 8 (---"-- 400,000)	252
2) Nitrogen kg/ha	
0	251
10	259
20	275
40	269

Due to severe drought conditions treatment effects were not significant.

Table 4. Effect of different levels of nitrogen on the seed yield of niger varieties (N-35, No-71, IGP-76 and Ootacamund) (Chhindwara - 1985)

Treatment N. kg/ha	Seed yield (kg/ha)
0	243
10	267
20	309
40	362
C.D (5%)	72

Table 5. The effect of different constituents of production technology on the seed yield of niger (Chhindwara - 1982, 1983)

Treatment	Seed yield (kg/ha)
T1 Farmer's practice	216
T2 T_1 + Improved variety	328
T3 T_1 + Fertilizer	337
T4 T_1 + Plant protection	314
T5 T_2 + T_3 (Imp. Var. Fert.)	358
T6 T_2 + T_4 (Imp. Var. Plant prot.)	336
T7 T_3 + T_4 (Fert. + Plant prot.)	337
T8 Full package	441

Table 6. The effect of intercropping niger with other oilseeds (groundnut, soybean, sesame) on the monetary returns (Tikamgarh - 1986)

Treatment	Yield kg/ha Main crop	Inter crop	Gross returns (Rs/ha)
Pure niger	193	-	963
Niger+G. nut (2:2)	110	240	1767
Niger+Sesame (2:1)	150	235	1604
Niger+Sesame (1:1)	149	254	3295
S.E. (m) ±		83.56	
C.D.5%		238.72	

Table 7. The effect of intercropping niger with different crops (soybean, paspalam scroficulatum, phaseolars, mango, P. radiaus, and cajaners and cajar) on the monetary returns. (Chhindwara - 1986)

Treatment	Yield kg/ha Main crop	Inter crop	Monetary returns* (Rs/ha)
Pure Niger	253	---	1263
Niger+S.bean (1:1)	253	139	1638
Niger+Kodo (Ps)(1:1)	181	282	1184
Niger+Moong(PR)(1:1)	211	481	3277
Niger+Urid (2:2)	222	456	3161
Niger+Red gram (2:2)	211	630	4256
C.D. (5%) Rs. 583.78			

*In another experiment niger+sorghum gave a monetary return of Rs. 3154 as compared to Rs. 1746 under pure niger.

fishing nets, ropes, etc. At present, the country is importing linseed fibre worth about Rs. 300 million for textile industry and an equal amount for defence products.

Considering the importance of the crop it was included under AICORPO since the very beginning. Initially, four research centres were given the mandate for this crop. During the sixth plan four more centers and during the seventh plan seven additional centres were established added. In this way now 15 research centres located in different agro- ecological zones of the country are undertaking work on different aspects of the crop. Recently dual purpose varieties like Jeevan (DPL-21) and Gaurav (LCK-151) have been released. In Madhya Pradesh there is one main centre at Raipur which mostly works on linseed cultivation under "utera" system and subcentres at Sagar and Powerkheda. Besides, substantial work is also being done at voluntary centre like Jabalpur/ Tikamgarh. The salient features of the work are as follows:

i) multi-resistant varieties like Jawahar-23 and RLC-6 (kiran) have been released.

ii) the optimum date of sowing under rainfed condition has been found to be from the second to the third weeks of October, which may be extended upto the first week of November under irrigated condition.

iii) the nitrogen has responded linearly upto 60 kg/ha. Even a small dose of 20 kg/ha has proved highly remunerative.

iv) a row spacing of 25 cm with a seed rate of 30 kg/ha giving the plant population of about 300,000 ha has been found to be optimum.

v) the different constituents of production technology like varieties, fertilizer, plant protection have significantly increased yield over farmers practice.

vi) intercropping linseed with wheat and gram and vice-versa has proved highly profitable.

In order to achieve the desired results in terms of productivity, cost/benefit ratio and total production, agro-technology is to be applied under sound and advance planning and with efficient management. Planning and management are a "no input" techniques which pay rich dividens without involving any additional cost.

The reader is requested to refer to Tables 8-13 for linseed.

Table 8. Grain yield of different levels of nitrogen under irrigated conditions at Tikamgarh.

Nitrogen (kg/ha)	Grain Yield* (kg/ha)	NUE	CBR
0	717	---	---
30	1023	10.2	10.2
60	1248	8.8	8.8
90	1307	6.5	6.5

* average of 2 years (1983, 84) and 5 vrieties (SPS 23-10, SPS 49-2, LS2).

Table 9. Grain yield of linseed as influenced by dates of sowing under irrigated conditions at Tikamgarh.

Dates of sowing	Yield* (kg/ha)
12th October	1632
22nd October	1716
1st November	1855
11th November	1717
22nd November	1162

* Average of 2 years (1983, 84) and 3 varieties (SPS 23-10, SPS 49-2, LS 2).

Table 10. Grain yield (kg/ha) intercropping and monetary return (Rs./ha) as influenced by different intercropping systems, 1983 and 1984 (Tikamgarh).

Treatment	Grain yield (kg/ha) Main crop	Grain yield (kg/ha) Inter crop	Gross Monetary return (Rs/ha)
(L)	1391	---	6710
(G)	----	2376	6763
(W)	----	2080	3240
L+G (1:1)	1119	970	7899
L+W (1:1)	725	896	5047
L+G (2:1)	1340	686	8097
L+W (2:1)	1052	722	6217
L+G (3:1)	1307	556	7704
L+W (3:1)	1176	503	6461
L+G (1:2)	843	1704	7443
L+W (1:2)	549	1319	5260
L+G (1:3)	645	1283	6497
L+W (1:3)	475	1569	4751
S.E (m) ±	Rs. 300/-		
C.D. at 5%	Rs. 967/-		

Table 11. Seed yield of promising linseed varieties (RC-1, RLC-3, RLC-6 R-1156) as influenced by various spacing and seed rate under irrigated conditions (Tikamgarh 1986)

Treatment	Yield (kg/ha)	Treatment seed rate/ha	Yield (kg/ha)
20 cm.	1270	20 kg.	1268
25 cm.	1400	30 kg.	1382
30 cm.	1234	40 kg.	1260
S.E. (m) ±	14.53	S.E. (m) ±	9.31
C.D. 5%	56.78	C.D. 5%	35

Table 12. Nutritional effect with special reference to sulphur on the linseed variety RLC-6 under irrigated conditions, 1987 (Tikamgarh).

Treatment	Yield (kg/ha)	Treatment	Yield (kg/ha)
Control	756	$N_{60}P_{0}K_{0}$	1156
$N_{20}P_{10}K_{5}$ (SSP)	1122	$N_{20}P_{10}K_{5}$ (DAP)	1078
$N_{40}P_{20}K_{10}$ (SSP)	1311	$N_{40}P_{20}K_{10}$ (DAP)	1156
$N_{60}P_{30}K_{15}$ (SSP)	1453	$N_{60}P_{30}K_{15}$ (DAP)	1300
$N_{80}P_{40}K_{20}$ (SSP)	1478	$N_{80}P_{40}K_{20}$ (DAP)	1433
$N_{100}P_{50}K_{25}$ (SSP)	1556	$N_{100}P_{50}K_{25}$ (DAP)	1467

S.E (m) ± 49.59, C.D. 5% 142.68

SSP contains about 12% sulphur.

DAP contains no sulphur.

Table 13. Mean seed yield (kg/ha) of different varieties of linseed as influenced by date of sowing under rainfed conditions, 1986 (Tikamgarh).

Date of sowing		Seed yield (kg/ha)
October 17		1277
" 27		1165
November 6		1030
" 16		909
	Date	
S.E (m)	15.1	
C.D.	48.7	

Advance planning

Taking into consideration the available natural resources (land, soil type, climate) and acquired irrigation-canal, tank, well, power-human, animal, machine etc., credit facilities, market, prevailing prices, etc., the hectrage under different crops may be decided and a systematic cropping plan be well prepared in advance with due provision of contingency planning. This has to be reviewed and modified at short intervals as warranted by the changed situation.

As per requirement of the cropping plan, the various inputs like improved seed, fertilizer, chemicals (herbieides fungicides insecticides, etc.) are to be procured well in advance of the season. Likewise, various implements, irrigation pump-motor, spray equipments, etc. are to be in working order.

Efficient management

i) Site selection: Soil type, topography, possibility of water harvesting if any may be considered.

ii) Thorough field preparation: This ensures weed control, moisture conservation and initial optimum plant population.

iii) Seed testing for viability and purity: This ensures satisfactory germination and prevents the introduction, through crop seeds, of noxious weeds like *cuscuta*, etc.

iv) Seed treatment with chemicals, biofertilizers, etc: This will provide protection against seed and soil-borne organisms, enrich the nitrogen status and enhance germination.

v) Timely sowing: This reduces the intensity of the attack of diseases and pest and moisture deficit and ultimately leads to higher production.

vi) Method of sowing: Line sowing proves beneficial over broad casting. Proper implements need to be developed for this purpose.

vii) Nutrient application: To be applied in proper amount in balanced form, (NPK in combination with minor elements like Zn, Fe, etc. where needed and other elements like Sulphur for oil seed, etc.) at the proper time (basal, top dressed, foliar spray, etc.) and with consideration of time of weeding, irrigation, etc.

viii) Timely weed control: Considering the crop growth stage, delayed weeding is not effective.

ix) Irrigation: At proper time, generally at tillering / branching, flowering and grain filling stages.

x) Timely harvest: To avoid shattering and other losses. Most of the time field workers fail to stick to these simple guide lines unknowingly or knowingly due to some avoidable/unavoidable circumstances resulting in significant losses.

Besides, having the vertical expansion of the crop in terms of raising the productivity by adopting improved techniques mentioned above, a thought is to be given for its horizontal expansion by way of increasing its hectreage in order to increase the overall production of these crops. Though possibilities are limited, a sizeable area can be increased.

i) Expansion on new area: There is sufficient area under culturable waste/grasslands, permanent/current fallows, part of which can be brought under these crops.

ii) Crop substitution: There is a sizeable area under less remureative crops like minor and lesser millets, a part of which can be assigned to these crops.

iii) Inter-cropping: By introducing these crops in other major cereal, pulse and even oil seed crops.

THE PRESENT STATUS OF NIGER AND LINSEED PATHOLOGY RESEARCH WORK IN INDIA

G.S. Saharan

NIGER

Niger (*Guizotia abyssinica* Cass) is cultivated in India in an area of about 600,000 ha annually chiefly in Madhya Pradesh, Orissa, Maharashtra, Bihar, Karnataka and Andhra Pradesh, on hill tops and slops. Although a number of diseases are known to occur, Table 1, on this crop in India but no systematic approach has been attempted to investigate any disease in detail. The information is available only on the occurrence and symptomatology of the diseases. As regards management, seed treatment with Thiram @0.3% has been found to protect seed rots along with higher seed germination. Spraying of Zineb @ 0.2% is useful for the control of leaf spot diseases (48, 49).

Table 1. Diseases of niger in India.

Disease	Cause
Powdery mildew	*Sphaerotheca sp.*
Leaf spot	*Cercospora guizoticola*
Wilt	*Ozonium texanum var. Parasiticum*
Root rot, stem rot and blight	*Rhizoctonia Solani,* *Macrophomina Phaseolina,* *Sclerotium rolfsii,* *Rhizoctonia bataticola,* *Alternaria alternata*
Seed rot	*Asperqillus* sp., *Cladosporium,* *Alternaria* sp. *Emericella* sp., *Fusarium* sp. *Phyllosticta* sp.
Bacterial leaf spot	*Xanthomonas campestris* pv. *guizotiae*
Phanerogamic parasite	*Cuscuta hyalina*

LINSEED

At present, we in India cultivate linseed in India is exclusively cultivated for seed in about 2 mill. ha of land which comes to about 25% of the total world acreage under this crop. Among rabi oilseed crops, linseed is next to rapeseed and mustard. It is an important oilseed crop of Uttar Pradesh, Madhya Pradesh, Maharashtra and Bihar, contributing more than 85% to its national acreage and production. The area under linseed is increasing in other states year by year. The diseases to which linseed is exposed and prone are many, Table 2, but Alternaria blight, rust, powdery mildew and wilt diseases are most damaging to this crop and have been investigated in depth.

Table 2. Diseases of linseed in India

Disease	Cause
Rust	*Melampsora lini*
Blight	*Alternaria lini,* *A. alternata*
Wilt	*Fusarium oxysporum f. lini* *Rhizoctonia bataticola*
Powdery mildew	*Oidium lini*
Root rot, stem rot and blight	*Macrophomina phaseolina* *Rhizoctonia solani* *Sclerotium rolfsii* *Sclerotinia sclerotiorum*
Leaf spot/Pasmo	*Colletotrichum lini* *Septoria linicola* *(Mycosphaerella linorum)*
Seed rot	*Aspergillus* sp. *Alternaria* sp. *Ascochyta linicola* *Botrytis* sp. *Cladosporium herbarum* *Colletotrichum lini* *Fusarium* sp. *Macrophomina* sp. *Polypora lini*
Phanerogamic parasite	*Cuscuta hylina*

Rust

Linseed rust caused by *Melampsora lini* (Ehrenb) Lev. causes severe epidemics year after year with losses estimated to range between 40 to 100% depending upon the amount of initial inoculum, time to first appearance of the disease and subsequent build up and dissemination of the pathogen. A reduction of 13.1% has been reported in oil content of heavily rusted plants (62).

Disease development

This has been studied mainly in relation to the prevalence of different races as a function of resgenes present in host cultivars and the number of unnecessary virulence genes present in the pathogen. Some studies have also been carried out to study the effect of light, temperature and humidity on uredospore germination, infection and disease development under field conditions.

Race prevalence in relation to virulence

It has been demonstrated (14) that races of flax rust attacking widely grown cultivars increased whereas races unable to do so, decreased. The predominant races were those carrying the smallest number of genes for virulence that permitted survival. In a recent study (56) relationship of virulence to race prevalence as hypothesized by Flor (14) could not be clearly established since races which were virulent on only one resgene as well as those virulent on 5 or 6 resgenes were equally rare.

Environment and disease development

Uredial development takes place at temperatures ranging from 7° to 30°C with optimum at 16-22°C (20). Infection was slight at 7-14°C and at 26-30°C. Subsequently, it was found (42) that temperature between 13°C and 21°C are most conductive to host infection and rust development, with symptoms appearing in 7 days. For infection of linseed by uredospores of *M.lini*, under controlled conditions of constant temperature and continuous leaf wetness, a temperature range of 15° to 25°C was found optimum (47). Considerably cultivar specificity with regard to the effect of light intensity on incubation and latent periods was recorded (52).

Although under controlled conditions, the latent period of *M.lini* was influenced considerably by light and temperature, under field conditions it is subject to the influence of a large number of environmental factors which may have suppressive or additive effects on each other and hence on latent period. Analysis of simple correlation coefficients indicated that environmental factors like temperature (TEMP), mean relative humidity (MRH), RH, and cloudiness (CD) have a highly significant positive correlation with latent period whereas MTEMP had a highly significant negative correlation. The variation explained by any of the combinations of variables was of a high order. Even a single environmental factor like number of days with relative humidity $\geq$90% could account for more than 92% of the observed variation in latent period. Thus, under field conditions, the latent period of *M.lini* is greatly influenced by duration of relative humidity of 90% or more (53).

Studies on the periodic increase in the number of pustules per tiller under field conditions showed that MTEMP had a significant negative correlation with rust development. When partial regression coefficients were tested in different combinations for the progress of rust, the partial regression coefficient for TEMP was significant in TEMP, MRH and CD and TEMP and CD combinations. The multiple regression equation build up from different combinations of variables for the progress of the disease with significant R^2 values explained the variation ranging from 39.9 to 61.5% (55).

Physiologic specialization

Physiologic specialization in *M.lini* on flax was first demonstrated by Flor (11), who developed a set of rust differentiating lines each supposedly carrying a single gene for resistance in the background of Bison susceptible to all the races occurring in North America by back-crossing (13,15). In the absence of availability of differential varieties developed by Flor the occurrence of 5 physiologic races based on reactions of 7 collections on 50 linseed cultivars was demonstrated in India (42). The information on the race-flora of linseed rust prevalent in India has been compiled (30, 36, 38, 42, 51, 58, 65). So far, 18 physiologic races have been found to occur in India. These have been designated, I-1 to I-17 and 43 in the order of their discovery as they do not correspond to any of the races mentioned in Flor's key except the later one. Out of these, 17 have been reported from Himachal Pradesh (38, 51, 58). Collectively, these races are virulent on resgenes L1 (Burke), L2(Stewart), L5(Wilden), L7(Barnes), L9(Bison), L10(Bolley Golden sel), M1 (Williston brown), M2(Ward), N(Bombay), P(Koto), and P1(Akmolinsk). On the basis of reaction to Bison, the Indian races can be separated into group A(I-1, I-3, I-4 and I-7) to which Bison is resistant and Group B(I-2, I-5 and I-6) to which Bison is susceptible.

Sources of resistance

Comprehensive screening of a large number of genotypes under artificial inoculation conditions against all the prevalent races of *M.lini* in India indicated LC 216, LC 255, LC 256, Ottawa 770B(L), Dakota(M), Vicotry A(M4), Tower (L8), Marshall (N2) and Pale blue crimped (L3) as excellent sources of resistance (51,53). Most of them carry single or few dominant genes for resistance to all the races in India and can be utilized for developing resistant cultivars. A large number of genotypes free from rust were reported (59,60). Amongst the recommended cvs. for growing in different regions of India (22), LC-54, Himalini, Jawahar-7, Jawahar-17, Jawahar-552 and JLS(J)-1 are resistant to rust. In AICORPO trials conducted for three years at different locations of India under UDN (uniform disease nursery), genotypes like LCK-38, LCK-59 and RLC-2 were found resistant (2).

Genetics of resistance

Studies on inheritance of resistance to *M.lini* in flax were initiated (12,13,21,40). In India, large number of cultivars have been screened against different races or with mixtures of races 8,9,28,34, 43,51,53). It was found that in cultivars, NP (RR) 262, NP (RR) 45 and NP (RR) 204, field resistance was controlled by one dominant gene, two complementary genes and two dominant genes, respectively (19,24,39,59). However, they did not use known races for these studies. In a subsequent study (25), resistance in NP (RR) 45 to race I-1 was found to be governed by two complementary genes. Genes for resistance to 5 Indian races of *M.lini* in the flax rust differentials and two allied species, *L.affricans* and *L.marginale* were determined (34,35). The differential cultivars Dakota, Ward, Cass, Victory-A, Polk and leona carry two resgenes operative against Indian races, while Bowman has three. Other differentials were found to be monogenic for resistance to races under study.

Resistance in LC 255 to races I-8 and I-9c was governed by 2 dominant genes, whereas torace I-9c, it was due to a single dominant gene (51,53). In LC 256 resistance to races I-8 and I-9c was also governed by two dominant genes. In LC 215, resistance to races I-8 and I-9b was due to single dominant genes but to race I-9c it was due to two dominant genes. Reaction of F_2 population of a cross between LC 216 and LC 255 to sub-race I-9b indicated that the gene for resistance in LC 216 is different from the genes for resistance in LC 255. LC 216 and LC 255 have one parent in common, viz., EI5643. Thus, LC 216 and LC 255 which are resistant to all the races against which they were tested, possess different genes for resistance to race I-9b and can be effectively used in incorporating broad-spectrum rust resistance in important cultivars. In cultivars K_2 and LC45 which have been released for cultivation in Himachal Pradesh, resistance to the widely prevalent race I-9c was governed by one dominant gene each. However, inoculation of these cultivars with different races showed that both these cultivars are susceptible to several races and hence their utility as donors for rust resistance is limited. Cultivar K_2 which is susceptible to many races, is resistant to the widely virulent race I-17 and may thus be useful as a source of resistance in other areas. A perusal of data on the virulence spectrum of different races shows that there is a large reservoir of resgenes still available for exploitation in breeding linseed cultivars for rust resistance.

Rust resistance in EC-77959 and A-7-1-1 is governed by the same gene (39) BS-44 carries two resgenes, one of which was the same or allelic to that of EC-77959 and A-7-1-1, Hira carries two resgenes different from others. EC-77959 is a useful donor owing to its resistance to both rust and powdery mildew. In a recent study using mixture of races (I-1 to I-7), inheritance of rust resistance in cvs. R-17, R0552, JLS(J), R-556 and ILS-73-25 was governed by a single dominant gene (19). Dominant duplicate gene was observed in Himalini, C-59 and Dhar local-2. Crosses between Dhar local-2x Himalini and Dhar local-2xC.59 exhibited 255R: Is indicating operation of 4 diverse dominant genes.

Annual recurrence

In the plains of India unlike other countries teliospores do not remain viable through the summer which is the critical period for their survival, as they are killed by exposure to intense heat in May to September (44). On the other hand linseed rust pathogen can survive in uredial form on self sown plants and among seeds in the form of stem bits bearing telia as contaminent in Simla and Kangra hills of Himachal Pradesh. Evidence has been obtained on the active role of such teliospores in initiating fresh outbreaks (33). From such places in the hills, uredospores are blown down to the foot hills and in the presence of high humidity the rust spreads to other places. In Kangra valley, rust out break has been reported in late October (47) and places like Gurdaspur, situated in the plains close to the valley get very early rust outbreaks.

Management

In Madhya Pradesh region, sow the crop early within third week of October and grow resistant cultivars like Jawahar-7, Jawahar-

17, Jawahar-552 and JLS(J)-1. In Punjab and Himachal Pradesh grow resistant cultivars like CL-54, LC-185, K-2 and Himalini. If required then spray the crop with Dithane M-45 or Dithane Z-78 (0.25%) @2 kg/ha or dust with Sulphur @17.5 kg/ha at 10 days interval. In hills diseased plant debris should be destroyed to reduce source of primary inoculum (2,48,49). The cultivars like K_2 and LC 45 which are resistant to some of the races should be grown in plains. However, in the hills the cultivars like LC 216, LC 255, LC 256 should be grown since these are resistant to all the prevalent races. It will curb the pathogen at source of perpetuation and will also check outbreaks and spread of rust to the plains (51,53).

Powdery Mildew

Powdery mildew of linseed caused by *Oidium lini* Skoric is only next in importance to rust. Most of the rust resistant cvs of linseed are highly susceptible to powdery mildew. When powdery mildew appears in severe form at early stage of the crop growth yield reduction is very high. Infected plants produce poor quality of seed and fibre.

Disease development

The pathogen is believed to perennate in soil on diseased plant parts through the formation of parethecia. In the next season when favourable weather conditions prevail, asci and ascospores are released which initiate the primary infection. Usually in Northern and Central parts of India disease appears in the last week of February and reaches its maximum level by the middle of March when the temperature is between 20-25°C and humidity is less than 65%. Rainfall is unfavourable for disease development.

Physiologic specialization

There are enough evidences that powdery mildew pathogen exists in different forms of pathotypes. To identify the pathotypes of *Oidium lini* occurring in India ten host differentials viz., LMH-7, LMH-27, LCK-24 , LCK 242, KL-37, A-4-3-2, SPS-48-5, SPS-19-13, R-552 and Chambal or T-397 have been identified (2).

Sources of resistance

ED-22587 and EC-22684 genotypes were reported to be free from powdery mildew under M.P. conditions by Agarwal (1975). After exhaustive screening of available germplasm under field and greenhouse conditions, four lines, viz., LC-216, LC 255, LC-256 and LC-269 were found highly resistant both in seedling and adult plant stages by Singh and Saharan (1979). Under uniform disease nursery trials conducted at different locations all over India for three years (2) have shown genotypes, viz., R-552, SPS-48-5, RLC-5, and RLC-19 as resistant to powdery mildew. Amongst the cvs recommended for growing in different regions, LC-185, LC-54, Himalini, and Jawahar-552 are resistant to powdery mildew under field conditions. High HCN (Hydro cyanic acid) content were reported in resistant genotypes like EC-77959 and EC-1456 whereas susceptible genotypes were low in HCN (41).

Inheritance of resistance

In an exotic collection, EC-9832 resistance to *O.lini* was reported to be governed by a single dominant gene (29) whereas one partially dominant gene was reported governing resistance in EI-5665 (3). In an exhaustive study (61) resistance to *O.lini* in each of the four linseed cvs, viz., EC-216, LC-255, LC-256 and LC-269 is conditioned by one dominant gene. Crosses between the resistant parents indicated that the same gene was present in all the cultivars and is designated as *Ol*. A single pair of dominant genes governing resistance to the two diseases, powdery mildew and rust individually was found (37). Resgenes for *M.lini* in EC-77959 appeared to be the same or allelic to that of A-7-1-1. The resgenes for *M. lini* and *O. lini* appeared to be tightly linked in EC-77957. This offers an opportunity to use it as a donor for evolving varieties resistant to the two diseases simultaneously.

Management

In Madhya Pradesh region sow the crop before the third week of October and grow resistant cultivar R-552. Under Punjab and Himachal Pradesh region grow K-2, LC-54 and LC-185 cultivars which are resistant to this disease. Spray Bavistin (0.2%) or Sulfex (0.3%) or Karathane (0.2%) or Wettable sulphur (0.25%) at weekly interval depending on the intensity of the disease. Proper coverage of the crop with fungicidal spray is essential to curb the disease (2,48,49).

Blight

It is caused by *Alternaria alternata* (Fr.) Kiessler. Leaf infection causes damage from 27 to 60%. However, bud infection can cause loss up to 90%. The disease is most harmful when buds and capsules are affected (6). There is significant negative correlation (r=0.7567) between the disease intensity and yield. Yield loss can be estimated through regression equation, Y=733.35-8.24X (17).

Disease development

The pathogen perpetuates through the seed and diseased plant debris. The temperature between 26-33°C and humid conditions are found to be most favourable for the growth of the fungus and for infection of the plant. If RH falls below 75% than disease development becomes restricted (17).

Source of resistance

All the recommended cvs. of linseed being grown in different parts of the country are susceptible to this disease. Under artificial inoculation tests, four genotypes, viz., FRW-12, EC-4162, My-1 and *Linum strictum* were found resistant to this disease (26,63). In AICORPO trials the genotypes of linseed namely KL-37 and LCK-240 were found resistant to this disease under uniform disease nursery trials conducted for three years at different locations (2) of India.

Management

Sow seeds after treatment with Bavistin (2g/kg seed) or Agrasan or Thiram @3g/kg seed to avoid seed borne inoculum. Grow resistant cultivars like, R-7, R-17 and R-552 in M.P. region. Spray with Dithane M-45 (0.25%) @2 kg/hac at 15 days interval depending on the intensity of infection (2). A mixture of calixin (0.05%) and dithane M-45 (0.25%) spray is very useful for controlling blight and powdery mildew both (2).

Wilt

Linseed wilt is caused by *Fusarium oxysporum* Scht. f.sp. *lini* (Bolley) Snyder and Hansen. Continuous cropping in the infected fields creates soil sickness. Up to 80% losses to the crop due to wilt pathogen was reported (57).

Disease development

The pathogen is soil borne and can survive in soil for many years. It has been isolated from the seed as well. It can be carried over by the infected root pieces in the soil from year to year during continuous cropping in the same field. The temperature between 25-28^{0}C is most suitable to get maximum infection with an optimum of 24^{0}C. At unfavourable soil temperature of 12^{0}C and 38^{0}C even susceptible cvs escape much damage (22,27). In India, It has been reported that the disease is favoured by low moisture and light sandy soils (18). Farmyard manure decreases the incidence of the disease. Potassium content of the plants has been reported to be correlated with their resistance to wilt (7).

Physiologic specialization

It has been demonstrated that wilt pathogen consists of several cultural and pathogenic races (4) which differ from each other in their cultural character, pathogenicity and temperature requirements. Antagonism exists between some races. Continuous cropping in the same field increases virulence of the pathogen.

Sources of resistance

The cvs like K-2, LC-185, LC-54, Himalini, and Jawahar-552 are tolerant to wilt disease. Genotypes namely, RIC-1, RLC-5, RLC-6, RLC-18, RLC-19 and R-552 have been found to be resistant to wilt pathogen tested at different locations under UDN for three years in AICORPO (2). BR-9, BR-29, Indore-1, Malvi-1, N.P.-12, Bison-69, Bison-70 and Canadian Western No.1 were found to be resistant to wilt (5).

Inheritance of resistance

When wilt resistant genotypes viz., BR-1, EC-544 and NP-RR 65 and rust resistant cv. Norman were crosed than in F_2 resistance to wilt and rust in respective parents was found to be governed by separate single pair of dominant genes. The resgenes for the two diseases in the parents showed independent assortment (28).

Management

Continuous cropping of linseed on the same field should be avoided to check the development of wilt inoculum in the soil. To eradicate seed borne inoculum seed treatment with Bavistin @2g/kg seed or captan or Thiram @3g/kg seed is essential. Grow tolerant/resistant cvs like R-552 in M.P. and K-2, LC-54, LC-185 and Himalini in H.P., Punjab and Haryana (2). It is believed that flooding of the field and crop rotation reduces wilt inoculum in the soil (48,49).

Gaps in Linseed Pathology Research, Future Priorities And Thrust

Most of us explain from time to time about the gaps in our knowledge on various aspects of our research work. It is not uncommon to hear statements that gives a few more staff or a little more in the way of funding and equipment, it would be a relatively simple matter to fill in these gaps. The task is more complicated than one would had envisaged since it is imperative to define and describe the resistance of gaps, where they are? what they are? and why they exist? I shall outline the gaps in linseed pathology research as under.

1. Identification of physiologic races: In India linseed rust race picture is based on their reaction on differentials developed by flor which are supposed to be apparently monogenic. However, later studies proved the presence of additional (L^9) gene in some of the differentials known to be monogenic for alleles in K, M, L and P loci. It implies, therefore that differentiation of races could have

been bliterated in the past, in relation to differentials carrying additional Bison-gene (L^9). So, it is very important to evolve monogenic differentials in the background of a universally susceptible local cultivar to know the precise race-picture in India. There is an urgent need to standardize host differentials for identification of pathotypes of wilt, blight and powdery mildew pathogens of linseed.

2. Genetics of resistance: Lines having single, two and three resgenes conditioning resistance to all the races have been indicated. To make resgenes more effective and to avoid repeated breakdown of resistance attempts should be made to incorporate more than one resgene in a single cultivar. Within limits of all elism a more efficient test for all elism is a study of test cross population. The study by using large test cross population is needed to incorporate more than 5 resgenes in a particular cultivar.

We quite often talk about multigene resistance and multiple resistance, the efforts in this direction can be made to locate genes effective against other diseases (powdery mildew, wilt, blight) in addition to rust.

Although manifestation of horizontal resistance/durable resistance in linseed to diseases has not been demonstrated but more studies should be conducted actively on the components of horizontal resistance.

The principle of gene deployment and gene pyramiding should be put into practice for the management of linseed diseases in India.

3. Epidemiology: To predict the development of linseed rust in epidemic form, more information is required on the analysis of environmental factors responsible for rust development in different agroclimatic zones of the country. Some basic studies on the prevalence of races in relation to virulence are needed to know their behaviour with regard to competitive virulence potential and ability to survive. Detailed study on the epidemiology of other diseases should be taken up on priority.

4. Annual recurrence: The role of southern hills in the survival and spread of the diseases needs attention. More information should be collected on the role of wild species of *Linum* for perpetuation of the pathogens and for sources of resistance.

5. Sources of resistance: The history is full of examples that in most of the host-parasite interactions repeated breakdown of resistance has resulted in depletion of genes for effective resistance. Attempts should, therefore, be made to search for new resgenes.

6. Control: The emphasis should be laid on the management of disease in linseed through management of genes, since it is easy to incorporate, deploy and do resgene pyramiding in this crop.

7. Information gap: Some problem arise in linseed research from lack of information on the work already done in India and in other countries. This can lead to expensive duplication of efforts. There is a great need for more newsletters, review articles and information leaflets which can present new data and results of recent research. There is also the problem of informal exchange of research data and material. I hope the present review will be helpful in filling the information gap to some extent on practical aspects of linseed diseases.

8. Co-operation gap: We have several times stressed for an interdisciplinary approach to research but in practice we have failed to implement it. Apart from cooperation or integration with other disciplines a joint research program of breeder and pathologist is must to develop disease resistant cultivars. Every effort should be made to encourage a team approach to tackle disease problems.

In conclusion one has to admit that pitfalls or gaps in linseed pathology research may be many more but filling of big gaps should be given priority so that linseed pathology research vehicle can move smoothly for keeping up present production and increasing future production of linseed in India.

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SAFFLOWER, NIGER AND LINSEED IN NEPAL

B.Mishra

Nepal is predominantly an agricultural country where nearly 90% of the population is engaged in agriculture. The total land area of the country is 147,181 km^2 out of which only 22% (3,130,000 ha) land is being cultivated. Rice, maize and wheat are the major food crops covering 49.92, 20.99 and 16.31% of the total cropped area. The total area under all oil crops in the country is 1,48,160 ha. The total production is 92,320 Mt. The yield of these crops is 623 kg/ha (1987/88). Agriculture has a very important role in Nepalese economy and it generates more than 60% of the total export earnings. Oilseed crops occupy about 4.49% of the total cultivated area and about 48.83% of the cash crop area. Rapeseed-mustard *(Brassica campestris* var. Toria) is the most important edible oil of the country.

However, groundnut *(Arachis hypogaea)*, sesame *(Sesamum indicum)*, linseed *(Linum usitatissimum)*, niger *(Guizotia abyssinica)*, safflower *(Carthamus tinctorius)* and castor (Ricinus communis) have been grown in the country for a long time. Sunflower *(Helianthus annus)* was grown in the country as a garden flower only but these days, it is also grown for edible oil purpose.

Geographical Distribution

The country can be divided into three agroclimatic regions, Figure 1.

1. Plains: includes Terai and inner Terai (upto 300 meters altitude). In these areas mostly rapeseed-mustard, sesame, groundnut and linseed are grown.

In Patches, safflower is also grown. In this belt, the total area under these crops is 111,090 ha and the total production is 62,890 Mt (Table 1). The yield is 566 kg/ha (1985/86). This region has maximum area and production.

Table 1. Area, production and productivity of oilseeds (agro-climatic region-wise), 1985/86.

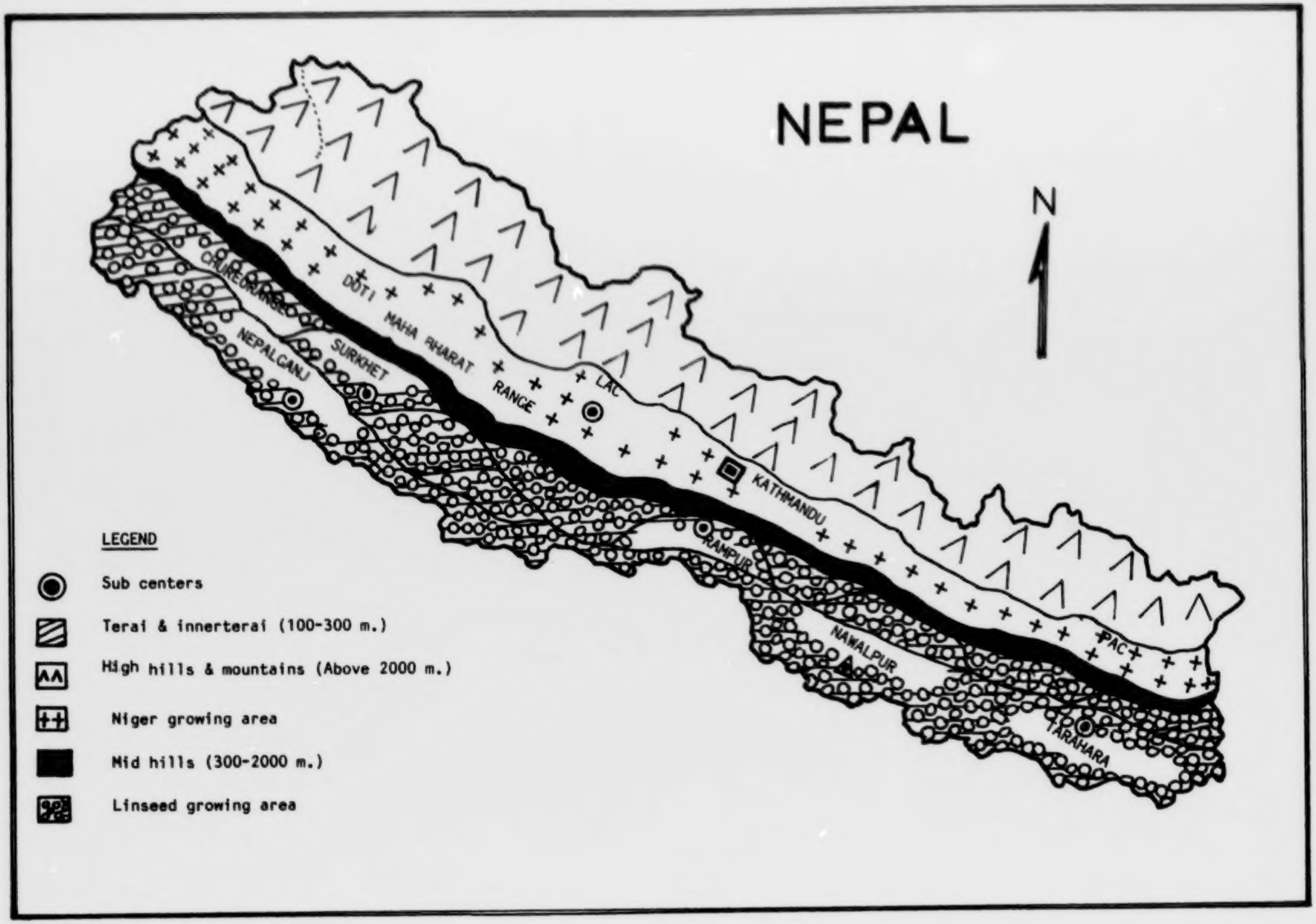
Agro-climatic region	Area (ha)	Production (Mt)	Productivity (kg/ha)
Mountain	1720	900	523
Hills	25,650	14,870	580
Terai	111,090	62,890	566

2. Mid-hills: includes valleys and small hills (between 300 to 2000 meters altitude). In this region, rapeseed-mustard, sesame, niger and groundnut are grown. The total area under these crops is 25,650 ha and the production is 14,870 Mt. The yield is 580 kg/ha (1985/86).

3. High hills: includes high mountains (above 2000 meters altutude). Area and production of these crops in this region is very low. The yield is also low (523 kg/ha). Table 2 shows the distribution of temperature and rainfall.

Future Strategies

The per capita availability of oils and fats in our country is only 7.4 g/day which is less than the minimum requirement of 18g as recommended by FAO. The national goal is to provide every citizen with 2250 calories per day by the end of 2000 A.D. Thus, oils and fats have very important role to play in providing calories to under nourished citizen. Keeping these points in view, National Oilseed Development Program (NODP) Nawalpur, Sarlahi, was established


NEPAL
N
CHUREDRANGE
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MAHA BHARAT RANGE
LAC
NEPALGANJ
SURKHET
KATHMANDU
RAMPUR
NAWALPUR
PAC
TARAHARA
LEGEND
Sub centers
Terai & innerterai (100-300 m.)
High hills & mountains (Above 2000 m.)
Niger growing area
Mid hills (300-2000 m.)
Linseed growing area

in 1976.

Table 2. Mean maximum and minimum temperature and rain fall (Average of 1985, 1986, 1987)

Month	Minimum temp. (^{0}C)	Maximum temp. (^{0}C)	Rainfall (mm)
January	11.9	22.7	1.5
February	12.7	24.3	16.8
March	15.3	23.2	12.5
April	20.0	34.3	35.6
May	22.4	35.5	72.0
June	24.6	34.5	393.0
July	25.0	33.1	607.0
August	25.0	33.1	501.0
September	24.5	32.4	378.5
October	23.5	31.4	154.3
November	18.0	29.6	0.0
December	14.0	26.6	20.1

Note: Data recorded from Bagmati irrigation project, Bagmati, Sarlahi.

Since then research work on different oilcrops has been started. We see that there is little scope for increasing the area under these crops as there are lots of possibilities of increasing the production per hectare, provided farmers get the required inputs in the form of high yielding good quality seeds, fertilizers and plant protection measures. Thus, there is a great responsibility on NODP to work sincerely so that the increasing population gets vegetable oil in the required quantity.

Safflower

Safflower *(Carthamus tinctorius)* has been grown in the country in small patches. Young leaves and thinnings of less spiny varieties are being used as vegetable. It is not grown as edible oil. There is no statistics available about its area and ptoduction. However, this crop is one of the eight mandate crops of this program. This crop has many good points. Hence, it will be a useful crop in the future, because of the following merits:

- only 18% of the cultivated land is irrigated and it does best on unirrigated land.
- it has well defined tap root system and can draw moisture and nutrients from depth in the soil profile.
- safflower oil is nutritionally superior.
- its leaves can be used as vegetable
- it can be used as protector for other winter crops and
- it has many industrial uses.

Despite its proven superiority, this crops has not become popular due to several constraints:

- traditionally, it is not grown as oilseed crop, hence farmers do not know about its quality
- since Toria oil is the major cooking oil, farmers have not given much attention to other neglected oil crops like safflower
- lack of research and extension work in the crop. Some research work was started some years back but due to lack of manpower and basic facilities it was discontinued and
- lack of technical know-how among the growers.

With the improvement in physical facilities and the increase in the number of research workers, this crop will certainly be an important oilseed crop of the country.

Major insect pests of safflower

1. Gram pod borer-*Heliothis armigera*
2. Capsule fly- *Acanthiophilus*

helianthi

3. Cut worm-*Agrotis spp.*
4. Stem fly-*Melanagromyza obtusa*
5. Safflower aphid-*Dactynotus carthami (Uroleucon compositae)*
6. Safflower caterpillar
   - *Prospalta capensis (periqea capensis)*
7. Termites
8. White grub

Important diseases

1. Phytophthora root rot caused by *Phytophthora drochsleri*
2. Sclerotinia wilt and rot - *Sclerotinia sclerotiorum*
3. Rust - *Puccinia carthami*
4. Alternaria leaf blight - *Alternaria carthami*
5. Cercospora leaf spot - *Cercospora carthami*

Niger

Niger *(Guizotia abyssinica)* is one of the major oil crops of the hills. However, it is also grown in Terai and inner Terai area. It is used as edible oil and has pleasant aromatic odor. The oil cake is suitable for cattle feed. It has different industrial uses. It is also used in picle preparation and as illuminating oil.

Cropping system

Generally, maize is the main food crop and rapeseed-mustard and niger are the main oilseeds of the hill people. Farmers take maize first then they plant niger or rapeseed *(Brassica campestris* var. Toria).

Although it is a popular crop of the hill it still has failed to draw the attention of researchers as well as extension people. Some basic research work is being carried out at NODP head quarters. However, it is not sufficient due to the lack of trained manpower and other basic facilities. We hope, in near future, some more research officers will join and some more facilities will come up, then better work will be carried out at different stations. In this year, (1988/89) one observation nursery was planted. The material was received from Ethiopia by the co-operation of IDRC. The result was not much satisfactory (Table 3). However, it has given many good observations.

Table 3. Observation nursery on niger (1988/89)

Lines	Plant stand at maturity	No. of flowers/ plant	Maturity days	Seed yield kg/ha
ER-0474	40	34	107	167.0
ER-0475	91	58	107	334.0
ER-0476	54	48	107	167.0
ER-0477	33	26	107	251.0
Palchauk local	223	45	104	650.0
Sarlahi local	263	81	102	1086.0

Due to poor germination, the actual yield potential was not realised; But all the plants looked healthy and vigorous. The highest seed yield (1086 kg/ha) was recorded from Sarlahi local and it had maximum flowers per plant. It matured in 102 days. The yield of other lines was low due to poor plant population.

Major insect pests of niger

1. Niger caterpillar-*Periqaea capensis*
2. Hairy caterpillar-*Diacrisia obliqua*
3. Leaf worm-*Spodoptera litura*
4. Cut worm-*Aqrotis spp.*

Major diseases of niger

1. Alternaria leaf spot-*Alternaria spp.*
2. Powdery mildew-*Sphaerotheca spp.*
3. Cercospora leaf spot-*Cercospora guizoticola*

Linseed

Linseed *(Linum usitatissimum)* has been grown in the country for years, particularly in the Terai and inner Terai regions. It is used as a cash crop and farmers get good return, though this crop is grown without any care. Farmers just sow some seeds and harvest whatever yield is received. Much of the production is exported to India and abroad. Some farmers use its oil as lubricant and as illuminating oil. It has other industrial uses such as soap, varnishes, paints etc.

Cropping system

In Nepal, rice is the main food crop throughout the Kingdom. Generally late rice is being planted. Farmers sow some linseed seeds in standing crop of rice when there is enough moisture. No fertilizer is being used.

Cropping patterns

Rice/Linseed -	Linseed is broadcasted as a relay crop in standing rice crop.
Rice -	Linseed + Lentil
Rice -	Linseed + Chickpea.

As this crop is very useful crop for small farmers, it is necessary to increase production per hectare. These days farmers harvest only 200 to 300 kg/ha of linseed. We don't have improved lines, however experiments on its agronomic requirements have been conducted. A fertilizer trial on linseed was conducted at NODP. Three doses of nitrogen (60,40,20 kg/ha) and two doses of phosphorus (40,20 kg/ha) and two doses of phosphorus (40,20 kg/ha) and a constant dose of potash (20 kg/ha) was applied.

Significantly higher yield (625 kg/ha) was recorded when 20:40:20 kg N:P:K/ha was applied as against zero fertilizer (336 kg/ha). This year we have planted one observation nursery, one fertilizer trial and one spacing trial on linseed.

Major insect pests of linseed

1. Linseed Gall fly- *Dasyneura lini*
2. Linseed caterpillar-*Laphygma exiqua*

Important diseases of linseed

1. Rust - caused by *Melampsora lini*
2. Wilt - *Fusarium oxysporum*

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COUNTRY PAPER ON OTHER OILCROPS IN BANGLADESH

M.A. Khaleque and Dilruba Begum

Bangladesh has been suffering from an acute shortage of edible oil since long time past. It has been producing only about 40% of its requirement and the remaining 60% is met by import every year. The local production has considerably increased during the last decade. In fact, it has almost been doubled during the First Five Year Plan (FFYP) and the Second Five Year (SFYP) period from 1975-85. The oil production in 1972-73 was only 51 thousand tons (Table 1). This went up to 58 thousand tons in 1981-82 and further increased to 92 thousand tons in 1984-85. But still the deficiency has remained more or less the same.

The requirement for a population of 110 m (@ 5 g/h/d) is estimated to be 202 thousand tons of oil in 1989-90 (TFYP). The local production has been aimed at about 112 thousand tons. Thus the deficiency will remain to be 90 thousand tons. This shortage will amount to almost 45%. The increased requirement arising out of the increasing population is responsible for this standing deficiency. Our major oilseed crops comprise rapeseed/mustard, sesame and groundnut. In addition, linseed, niger, sunflower, safflower are also grown in the country (Table 2).

Table 1. Area and production of Oilseeds from 1972-73 to 1984-85.

	Area (000'acre)	Production (000' tons)	Equivalent Oil (000' ton)	Source
1972-73	648	165	51	Accelerated Winter Oilseed Improvement and Development Programme.
Avg. 5 yrs. upto 81-82	673	176	58	Bangladesh Bureau of Statistics
1984-85	702	271	90	- do-
1984-85	928	275	92	Department of Agriculture Extension.

Table 2. Name of oilseed crops in Bangladesh

English name	local name	Scientific name	Remarks
Rapessed & Mustard	Sarisha	I. *Brassica campestris*	Widely cultivated area 1,62,000 ha
		II. *Brassica juncea*	Area 40,500 ha
		III. *Brassica napus*	Prospective for future cultivation.
Groundnut	Cheenabadam	*Arachis hypogaea*	Second in production among the oil crops. Area 20,000ha
Sesame	Teel	*Sesamum indicum*	Area 39,000 ha
Niger	Garzon Teel	*Guizotia abyssinica*	Minor oilcrop
Safflower	Kusumful	*Carthamus tinctorius*	Minor oilcrop
Sunflower	Surjomukhi/Surjaphul	*Helianthus annus*	Minor oilcrop
Soybean	Soybean	*Glycine max*	20% oil and 40% protein
Castor	Bheranda	*Ricinus communis*	Industrial oil
Linseed	Tishi	*Linum usitatissimum*	Industrail oil, Area 14, 700 ha
Cotton seed	Tulabeej	*Gossypium hirsutum*	20-22% oil

The status of linseed, niger, and safflower, minor oilseeds are been described below:

A. Linseed

Status

Linseed is both oil and fibre crop, but it is produced in Bangladesh for the purpose of oil extraction only. In terms of area under oilseeds, linseed stands fourth after rapeseed-mustard, sesame and groundnut. In 1981-82 its area was 15,134 ha with a production of 7,865 tons @ 533 kg/ha. Linseed is cultivated extensively in the greater districts of the northern region namely, Faridpur, Pabna, Jessore, Rajshahi, Kushtia and Tangail (Fig. 1).

Variety

There is only one recommended variety of linseed in Bangladesh. Its yield ranges 1000-1100 kg/ha and matures in 100-110 days. It is a dwarf variety and has blue flowers and contains 8-10 primary branches with many secondary branches. The next selection P-14-25 of Pakistan origin is promising, but matures in 125-130 days with higher yield potential (1200-1300 kg/ha).

Crop sequence

Linseed is cultivated both as sole and mixed crop. It is grown as mixed crop with mustard, chickpea, chilli or coriander in the greater districts of Jessore, Pabna and Tangail. The following cropping patterns are followed for linseed with other crops (See also fig. 2).

Summer (Kharif-1)	Autumn (Kharif-II)	Winter (Rabi)
Aus rice/Jute	T.Aman rice	Late linseed
Aus rice/Jute	Fallow	Early linseed
Aus rice/Jute	Fallow	I.Linseed+Mustard II.Linseed+Chickpea III.Linseed+Chilli +Coriander

Oil extraction and uses

Linseed contains 35-38% oil in the seed (Table 3). About 28% of the oil may be extracted from linseed by bullock driven extraction unit called "Ghani". Seven to ten percent oil is retained in the cake. Its oil is mainly used for industrial purpose and in greezing machines, varnish and soap making, etc.

Table 3. Some important constituents of oilseeds

Crop	Variety	Oil %	Protein %	Oleic acid (18:1) %	Linoloic acid (18:2) %	Linolenic acid (18:3) %	Erucic acid (22:1) %
Rapesse & Mustard	Tori-7	40.2	21.5	15.0	13.4	9.3	50.1
	Rai-5	39.5	22.0	11.0	16.0	11.0	48.2
	TS -72	42.7	24.0	13.7	12.0	9.4	55.1
	SS -75	44.5	25.6	14.2	14.1	8.5	55.5
Groundnut	DA -1	48.2	22.7	44.9	34.3	2.8	Nill
	DG -2	48.0	22.3	48.2	32.3	2.5	Nill
Sesame	T -6	44.0	19.7	44.4	45.2	Trace	Nill
Sunflower	DS -1	41.3	27.5	37.0	55.4	Trace	Nill
Safflower		40.0	23.0	9.7	81.0	-	Nill
Niger		39.7	23.9	-	-	-	Nill
Soybean		20.1	43.2	24.6	52.0	8.0	Nill
Linseed		38.0	21.8	-	-	-	-

Source: Oilseed project, BARI.

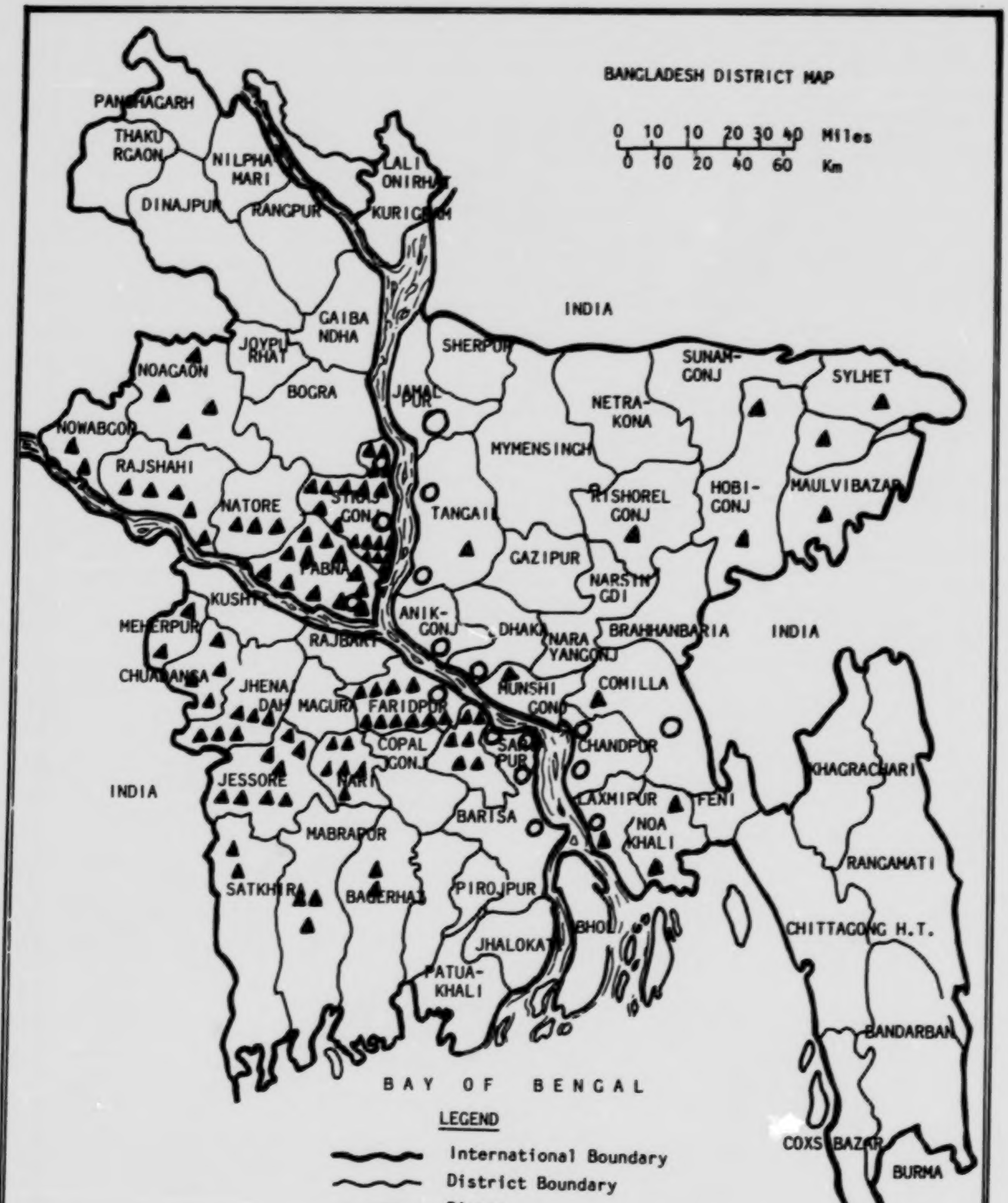
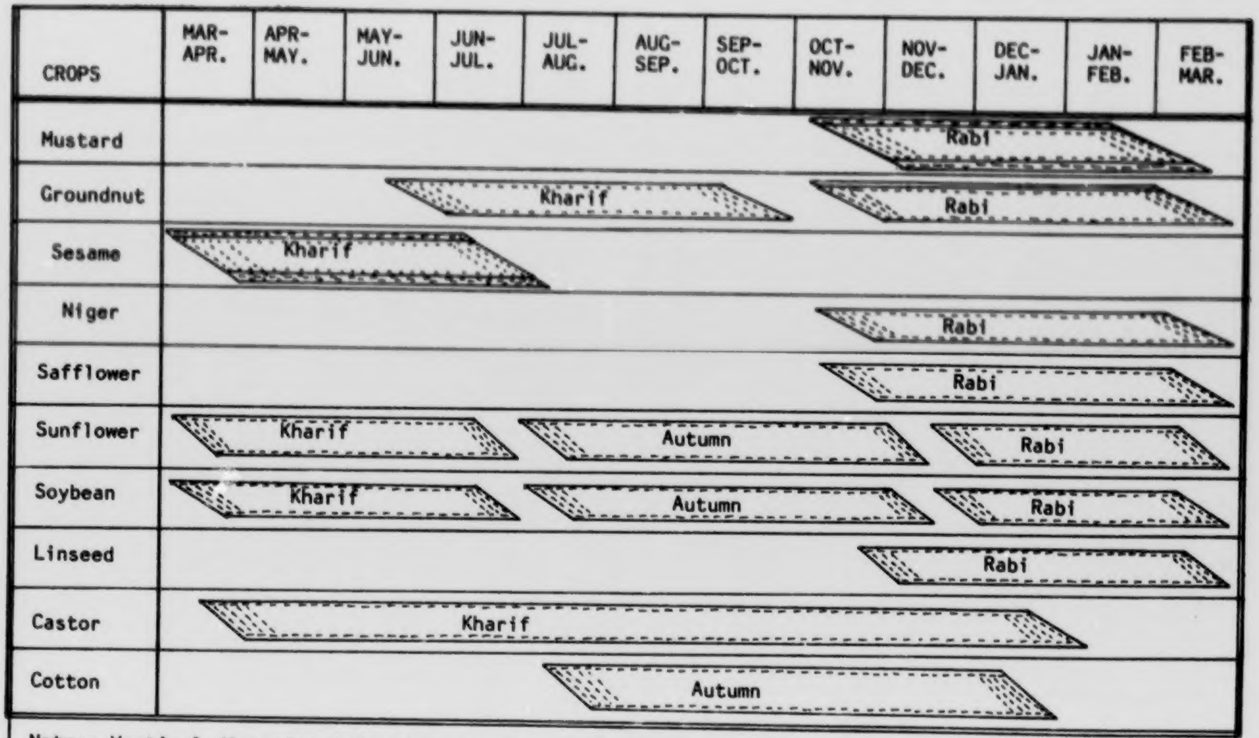

BANGLADESH DISTRICT MAP
0 10 10 20 30 40 Miles
0 10 20 40 60 Km
PANCHAGARH
THAKURGAON
NILPHAMARI
LALMONIRHAT
DINAJPUR
RANGPUR
KURIGRAM
GAIBANDHA
INDIA
JOYPURHAT
SHERPUR
SUNAMGONJ
SYLHET
NOAGAON
BOGRA
JAMALPUR
NETRAKONA
NOWABGONJ
MYMENSINGH
RAJSHAHI
NATORE
SIRAJGONJ
TANGAIL
KISHOREGONJ
HOBIGONJ
MAULVIBAZAR
PABNA
GAZIPUR
NARSINGDI
KUSHTIA
MANIKGONJ
DHAKA
NARAYANGONJ
BRAHMANBARIA
INDIA
MEHERPUR
RAJBARI
CHUADANGA
JHENAIDAH
MAGURA
FARIDPUR
MUNSHIGONJ
COMILLA
CHANDPUR
GOPALGONJ
SARIATPUR
KHAGRACHARI
INDIA
JESSORE
NARAIL
LAXMIPUR
FENI
NOAKHALI
BARISAL
KHULNA
RANGAMATI
SATKHIRA
BAGERHAT
PIROJPUR
BHOLA
CHITTAGONG H.T.
JHALOKATI
PATUAKHALI
BANDARBAN
BAY OF BENGAL
LEGEND
International Boundary
District Boundary
Rivers
Linseed Growing Area
Niger Growing Area
COXS BAZAR
BURMA

Fig. 1. Linseed and Nigerseed Growing Areas in Bangladesh.

Soil Resources Development Institute (SERDI).



Note:- Vertical dimension indicates area covered by the crop and horizontal dimension period of crop.

Fig: 2. Oilcrop Growing Calender.

B. Niger

Status and prospect of the crop

Niger is a minor oil crop, but contains good quality edible oil. It is mostly grown in greater Comilla, Jamalpur and Faridpur districts and in different char areas (Fig. 1). It is tolerant to water logging and requires no input. Usually farmers grow it in poor soil, virtually without any management. The usual practice is to broadcast the seeds in "Char" areas (sandy basin of river) after receding monsoon water. As a result the yield is poor (500-600 kg/ha). Separate statistics of its area and production is not available. It is included in the other oilseed group alongwith safflower, sunflower and soybean. Niger oil can be extracted easily by local "Ghanis". There was no officially released variety of niger until recently. Farmers used to grow local cultivars and keep their own seeds for future use. The first official variety, namely, Nig-1 (shova) has been released in November, 1988. It is a selection from Comilla region and is an early variety with short stature usually grown in winter. The yield is 1000-1200 kg/ha.

Disease and insect

No disease and insect incidence was observed in niger in Bangladesh condition.

Problems

Niger is a minor oil crop with low yield. High yielding variety is an urgent need for its promotion. The locally available materials lack in variability.

Utilization

Niger seed is usually crushed in local 'ghanis' with or without mustard seeds and used as cooking oil by the farmers.

C. Safflower

Status and prospect

Safflower produces a high quality edible oil, but is a minor oil crop. The crop is not grown as sole crop. It is usually grown as fence around the field pretecting other crops. The oil of safflower is used as hair oil and the petals as dyeing material.

Variety

No recommended variety is available in Bangladesh. One variety is already selected namely saf-1 ("Demra"), but not yet released. The yield per hectare ranges from 2000-2200 kg. Oil percentage of "Demra" is very low (only 20%). Another variety named S-400 has also been selected. It has high oil content (38-42%). This is an exotic variety from the USA.

Problems

Safflower has comperatively low oil content in seed and the crushing of oil is very difficult in local methods. It is difficult to handle the crop due to the presence of spines.

COUNTRY REPORT ON LINSEED AND SAFFLOWER IN PAKISTAN

Masood A.Rana [1], Mohammad Sharif [2], and Altaf H.Chaudhry [3]

Linseed *(Linum usitatissimum)*

A. Area and production

Linseed is a non-edible oil crop grown primarily for industrial purposes. It is grown on about 10,500 ha giving 5600 tons of linseed in Pakistan under irrigated and rainfed conditions, Table 1. Province-wise area and production is given in Table 2. About 68% of the area is located in the province of Punjab and the rest in Sind. Gujranwala and Faisalabad are the major growing areas in Punjab. Multan and Bahawalpure are also important linseed growing districts of Punjab. In Sind, Larkana is the major linseed producing area.

B. Varieties

Not much work has been done on the development of linseed varieties. L-1 is the only variety which is grown commercially in the country. It is medium tall attaining height of 60-75 cm and takes 145 days to mature. Another variety, Pr-2/4, which is in the pipeline is 10 days earlier than the L-1. Its yield potential is also a little higher than L-1.

C. Average yield

Average yield of linseed is considerably low in Pakistan (Table 3) as compared to other developed countries.

D. Scope

Linseed is generally grown as mix crop with field peas, rapeseed-mustard and wheat. As sole crop, it is usually grown in rainfed areas and on "Dobari" lands (land vacated by rice crop, where subsequent crops are grown usually without irrigation). As irrigated crop and with optimum inputs, yield as high as 2800 kg/ha can be obtained.

Table 1. Area and Production of, linseed and safflower in Pakistan from 1790-71 to 1986-87

	Area ('000 ha)		Production ('000kg)	
Year	Linseed	Safflower	Linseed	Safflower
1970-71	6.17	0.10	3.38	0.07
1971-72	7.68	0.05	4.13	0.04
1972-73	8.80	-	4.80	-
1973-74	9.17	-	4.80	-
1974-75	7.95	-	4.40	-
1975-76	7.92	-	4.46	-
1976-77	7.93	-	4.36	-
1977-78	10.27	0.04	5.62	0.04
1978-79	12.52	0.23	6.65	0.22
1979-80	10.28	0.22	6.26	0.24
1980-81	10.71	2.38	6.51	2.16
1981-82	9.81	4.23	5.90	4.40
1982-83	8.41	4.13	5.06	4.45
1983-84	8.73	2.87	4.99	3.09
1984-85	9.42	2.88	5.17	3.14
1985-86	10.49	2.70	5.62	2.90
1986-87	-	3.00	-	2.80
Annual growth rate (%):				
	3.37	3.36	3.23	3.78

Source: Agricultural Statistics of Pakistan, 1986 and personal communication with Ministry of Industries.

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[1]. National Agricultural Research Centre,

[2]. Ministry of Food, Agriculture and Cooperatives,

[3]. Agricultural Research Institute, Tandojam.

Table 2. Province-wise area and production of linseed and safflower from 1980-81 to 1986-87

	Area (000 ha)				Production (000 tone)			
Year	Punjab	Sind	NWFP	Total	Punjab	Sind	NWFP	Total
Linseed:								
1980-81	9.6	1.1	0.02	10.7	6.0	0.5	-	6.5
1981-82	7.9	1.2	0.67	9.8	5.1	0.5	0.3	5.9
1982-83	6.7	1.7	0.03	8.4	4.3	0.7	0.02	5.1
1983-84	6.2	2.6	-	8.7	4.0	0.9	-	5.0
1984-85	6.4	3.0	-	9.4	4.1	1.1	-	5.2
1985-86	7.2	3.3	-	10.5	4.4	1.2	-	5.6
1986-87	-	-	-	-	-	-	-	-
Safflower:								
1980-81	0.62	1.71	0.047	2.38	0.19	1.86	0.01	2.16
1981-82	0.27	3.93	0.036	4.23	0.11	4.28	0.01	4.40
1982-83	-	4.09	0.038	4.13	-	4.44	0.01	4.45
1983-84	-	2.83	0.040	2.87	-	3.08	0.01	3.09
1984-85	-	2.88	-	2.88	-	3.14	-	3.14
1985-86	-	2.70	-	2.70	-	2.90	-	2.90
1986-87	-	3.00	-	3.00	-	2.80	-	2.80

Source: Agricultural Statistics of Pskistan, 1986 and personal communication with Ministry of Industries.

Table 3. Comparison of average yield of linseed in Pakistan and other countries.

Country	Average yield (kg/ha)
Pakistan	583
India	225
Canada	893
USA	794
Argentina	766
China	722
Egypt	1207

Source: FAO Production Year Book, Vol. 40, 1986.

Proper crop promoting activities and price incentives can certainly help increase area and average yield of this crop. The greatest scope for increasing area is expected to be in mixed cropping with rapeseed-mustard and wheat.

Safflower *(Carthamus tinctorius)*

A. Introduction

In Pakistan, safflower has been grown from time immemorial and was used as a source of dye, medicine and human food. Its close relative, "Pohli" *(Carthamus oxycantha)*, an abnoxious weed, is widely distributed throughout the country. Safflower did not gain any attention as an oilseed crop and has remained neglected until recently.

Evaluation trials of safflower were initiated at Agricultural Research Institute, Tandojam, in 1968. Early investigations indicated its high yield potential and proved that it can be successfully grown as an oilseed crop in Sind. Proper attention has not yet been given to the crop at other provincial research stations and its commercial worth has not been evaluated. Some work has also been done at NARC, Islamabad, which indicates that it can also be successfully grown under rainfed conditions of Islamabad and the surrounding areas.

B. Area and production

Area and production of safflower in

Pakistan are given in Table 1 from 1970-71 to 1986-87. Safflower has been grown on very small area and there was high fluctuation of area from year to year. During 1970-71, it was planted on 103 ha only, which reduced to 53 ha next year (1971-72) and then it was not planted for five years in the country.

In 1976-77, the seed division of Ghee Corporation of Pakistan (GCP) was created to promote oilseed crops which undertook the task to increase the area of safflower in the Sind province. As a result, safflower was planted on 35 ha in 1977-78 and area increased slowly to 4227 ha in 1981-82; but once again, it dropped to 3000 ha in 1986-87, Table 2. A total of 2800 t of safflower seed was produced during 1986-87.

In spite of all efforts made by GCP and ARI, Tandojam, to push this crop, the area under safflower has not increased and is highly fluctuating from year to year. This clearly indicates: (i) hesitation of farmers in accepting it as a crop, and (ii) magnitude of constraints faced by the crop preventing its spread in the country.

C. Distribution of area

Province-wise, area and production from 1970-71 to 1986-87 are given in Table 1. In 1983-84 about 97% of the total area under safflower was planted in Sind and rest of the 3% in NWFP. But during 1984-85 and afterwards it was grown only in Sind. In 1980-81 an attempt was made to grow safflower in Punjab when 621 ha was planted. The efforts did not become fruitful because the crop was not taken up by the farmers of Punjab. In Sind during the last 7 years, area under safflower has increased from 2380 ha in 1980-81 to 3000 ha in 1986-87 registering an annual growth rate of (+) 3.36%, whereas area in NWFP has decreased slowly upto 1983-84 with a negative growth rate of 4.1% per annum and now disappeared completely.

Area under safflower cultivation in Sind is distributed in Sukkur and Hyderabad divisions. About 56, 24, 10, 2% of total area in Sind is located in Shikarpur, Larkana, Jaccobabad, and Sukkur districts, respectively, which together is 92% area in Sukkur division. The rest of the 8% of safflower area is located in Dabbu district. In NWFP safflower is grown in D.I. khan and Bannu districts only.

D. Varieties

World germplasm was evaluated at Agricultural Research Institute, Tandojam and variety Gila (from USA) was released in 1974 for commercial cultivation. But it was not accepted by the farmers because of its spiny nature. Therefore, a spineless variety Thori-78 was selected from the world collection. This variety was about 20% low yielding than Gila both in irrigated as well as in "dobari" conditions (getting a crop after rice without irrigation). Its oil content is 32% as compared to 36% in Gila and is also later in maturity than Gila.

E. Average yield

Although average yield of safflower in Pakistan is the highest in the world (Table 4), however, it is quite lower than the yield potential exploited in the research plots. There has been no improvement in the national average yield during the last 10 years. It was 1114 in 1977-78 and 1074 kg/ha in 1985-86.

F. Scope

Safflower is native to this area

and has been grown for centuries in some areas of Pakistan. Safflower has deep root system which makes it extremely drought resistant. It has shown good performance in rice (dobari) areas of Sind and it appears that safflower can be grown successfully in rainfed areas of Punjab and NWFP. Well organized and strong promotional program will help make safflower a successful crop.

Table 4. Comparison of average yield of safflower in Pakistan and other countries.

Country	Yield (kg/ha)
Pakistan	1067
India	372
Spain	842
Mexico	869
Portugal	444
USA	899

Source : FAO, Production Year Book, Vol. 40, 1986.

Yield potential exploited in research plots has indicated that safflower can yield as high as 3.0 t/ha. Even the farmers have obtained yields as high as 2.5 t/ha under irrigated conditions and 2.0 t/ha without irrigation and under poor crop management conditions. Safflower has been grown successfully in a rotation with rice in Sind as "dobari" crop which suggests that it has a potential in rice area of northern Sind and adjoining areas of Baluchistan.

Safflower gave very good yields under rainfed conditions of Islamabad and Fateh Jang. Six acres of safflower variety Thori-78 were planted at farmer's field in Fateh Jang, district Attock, by the Oilseed Program, NARC, during rabi 1985-86, where it gave an average yield of 1250 kg/ha. These results are very encouraging and indicate that safflower can also be promoted in Pothowar region where a lot of area remains fallow every year. It can also be planted in Mansehra successfully where "pohli", a wild relative of safflower, grows very well as a weed. In irrigated areas of Gujranwala district, average yield of 2000 kg/ha was obtained from demonstration plots on farmers' fields after rice indicating that safflower crop has also good prospects in the rice growing areas of Punjab.

Constraints for Low Yield

General:

(a) Non-availability of high yielding and improved varieties.

(b) Lack of seed production and distribution system for oilseed crops.

(c) Insufficient use of inputs especially fertilizer and inadequate cultural practices.

(d) Use of marginal land.

(e) Lack of plant protection measures and hence damage by insect pests and diseases.

(f) Lack of credit for the purchase of logistics to grow oilseed crops.

(g) Lack of farm machinery for planting, harvesting and threshing.

(h) Inadequate research support to develop improved production technology for various agro- ecological situations.

(i) Poor dissemination of production technology.

Safflower

(a) Long duration crop taking 160-180 days to mature.

(b) Spiny nature of the crop causes problems during harvesting and threshing which is a major reason of non-acceptability of this crop by the farmers.

(c) Bird damage at maturity.

(d) Low procurement prices.

(e) Defective procurement prices.

(f) Leaf blight disease and aphid resistance.

Linseed

(a) Non-availability of high yielding varieties. Varieties presently available for commercial cultivation are late maturing and low yielding.

(b) Lack of improved production technology.

(c) Linseed wilt, powdery mildew and pod borer.

Proposed Future Strategy

(1) Strong research programs should be started for the evaluation of world germplasm to develop varieties having desirable characteristics such as high yield, high oil content, early maturity, and resistance to leaf diseases and black aphid.

(2) Development of production technology suitable for different areas such as: (i) "dobari", (ii) river line, (iii) rainfed, and (iv) irrigated areas.

(3) Crossing of safflower with "pohli" and evaluation of progeny for high yielding ability, early maturity and wider adaptability.

(4) Development of varieties resistant to salinity and drought.

(5) Evaluation of safflower in irrigated areas with high water table where deep root system of safflower can both use subsoil water and help in lowering the water table.

(6) Development of improved harvesting and threshing techniques/equipments.

(7) Development of international linkage for:

- Provision of germplasm to strengthen the genetic base for variety development programs.
- Establishment of sound seed production system for oilseed crops.
- Manpower training in breeding, pathology and agronomy of the above oilseed crops.
- Present IDRC Network arrangement for inter-regional collaboration on oilseed crops should be effective for exchange of scientific information, seed material and technical know-how.

PRESENT STATUS OF SAFFLOWER IN EGYPT

Badr A. El-Ahmar

Safflower (*Carthamus tinctorius*) is an ancient oil crop in Egypt. It was planted and used as a row material for many industries in Pharaonic era. The extracted oil was used as an edible and as painting oil. The petals were used as a source of pigment for clothes.

Safflower plant was also used as a border for winter crops like wheat, barley and fababean. The majority of the area was planted in upper Egypt, as a border of each farmer after flooding season.

This area was cultivated mainly for petals and used for salted food conservation and the seed was used for bird feeding.

After high dam, continuous irrigation system was established and the area occupied by cotton in upper Egypt increased, and the area occupied by safflower decreased from 4000 faddan to less than 10 faddans (1 faddan = 4,200 m^2).

Due to the severe shortage in national edible oil production and the increase of annual consumption, and the limitation of edible oil sources for national extraction which depend mainly on cottonseed and soybean, it is essential to have other sources of edible oil. Those new sources are sunflower (summer) and rapeseed (winter) for new or old lands under irrigation. Safflower was devoted to the area which is rainfed. The annual precipitation ranges from 100 to 150 mm and in some years it reaches 200 mm. This area is located along the north coast and estimated to be more than 40,000 faddans.

Breeding Objectives

The breeding objectives of safflower under rainfed conditions are discussed below:

1. Drought resistance

To select drought resistant varieties with a good spreading root system, high capability for water uptake and short duration or high growth rate. This is the main objective in safflower breeding program. For that, the available germplasm (80 landraces and introductions) were sown this season under rainfed condition in north coast area, for screening this material according to their performance.

2. Spineless varieties

Most of the agronomic practices are done by hand, so spineless varieties are preferred. However, their yield is low.

3. Early maturing variety

The amount of rainfall is higher January and February, and hence, an early maturing variety with a reasonable seed and oil yield is satisfactory.

4. Resistance to broomrape

Broom rape is a problem which spreads all over the country. *Orobanche carinata,* which attacks safflower, is more dangerous. Fortunately, there is a wide variability of susceptbility within the available germplasm. A breeding program for broomrape control will be started next season.

5. Resistance to salinity

The new land in north coast is characterized in many places by high salinity. So, a variety which can tolerate or resist salinity is important for cultivation in this area.

The future expansion of safflower will be under rainfed areas. Since this area is cultivated to barley, an intercropping program should be conducted to give an answer for:

- suitable intercrop ratios,
- suitable plant density for both crops, and
- suitable varieties with minimum competition and reasonable yield per unit area.

We believe that expansion of safflower production in this area will offer a new source for edible oil and assist in increasing the national production.

PROGRESS IN LINSEED ON-STATION AND ON-FARM RESEARCH IN ETHIOPIA

Hiruy Belayneh, Nigussie Alemayehu and Getinet Alemaw

Abstract

It is estimated that the total area under linseed exceeds 100,000 ha. However, the national average seed yield is low mainly due to the poor traditional technologies in use. As a result of extensive testing, four high yielding stable improved varieties, namely Victory, Concurrent, CI-1525 and CI-1652 have been released for general cultivation. The latter two are in production currently. The agronomy trials showed that timely planting and weeding are important. The on-farm trial results indicated that linseed yield can be increased substantially by using the improved varieties and management practices. Hence, there is a large room for improving the current average national linseed yield of the country. Weeding of this crop is a profitable proposition. Fusarium wilt and pasmo are recorded as important diseases on linseed. The major insect pests are African bollworm and golden plusia. Chemicals are available to combat these insect pests.

Ethiopia is considered to be the center of diversity for linseed (*Linum usitatissimum* L.) (13). It is the second important oil crop after noug in the country and is grown widely on the highlands for its seed (19). The area under this crop is about 107,270 ha, with an average yield of 357 kg/ha (5). The poor yields under farmers' conditions are partly due to a heavy weed infestation. The main producing areas are in Arsi with adjoining areas in Bale and the Chercher mountains, in eastern Wellega, eastern Gojjam around lake Tana, the Semien mountain, Tigri, Eritrea, south-west Welo and Shoa (19). The crop is commonly cultivated on subsistence level at altitudes between 1800 and 3000m with an annual rainfall above 450 mm (13, 19). It grows on almost all types of soils except dry sands and poorly drained heavy clays. It is often grown on marginal and sub-marginal rainfed soils as pure crop.

A number of options are now available for better returns per unit area. This paper will summarize the promising results available so far.

On-Station Activities

Variety development

The objective of the breeding program is to develop high yielding stable cultivars with resistance to fusarium wilt, pasmo and powdery mildew.

Nearly all linseed varieties grown at present are landraces. Work on the indigenous landraces consisted mainly of making collections, evaluation and maintaining the germplasm. About 470 local collections have been characterized (11). In general, the Ethiopian linseed are short in height and small seeded. On the other hand, as a result of the introduction of exotic materials of diverse origin and extensive testing, four high yielding and stable exotic varieties (Victory, Concurrent, CI-1525 and CI-1652) have been released to producers. The latter two-bold seeded varieties were released in 1984 after fulfilling the pre-release requirements (10). CI-1525 and CI-1652 were improved through mass selection at Holetta from materials originated in France and Ireland, respectively, and have done well nation wide under both fertilized and unfertilized conditions (Tables 1-5).

Table 1. Summary of seed yield in kg/ha of the improved and local varieties in the linseed national and extension trials grown at 16 sites in five Agricultural Development Zone (ADZ) with 23/23 kg/ha of N and P_2O_5 fertilizer (F_1) or without (F_0) 1984-1986 crop season (7,15,17)

Agricultural Development Zone	Site	VARIETIES					
		Improved[1]			Local		
		F_0	F_1	Mean	F_0	F_1	Mean
Central	Sheno	858	967	913	705	871	788
	Holetta	1719	1860	1790	1450	1633	1542
	Debre Zeit	1615	1487	1551	1296	1233	1265
	Goha Tsion	961	1163	1062	813	900	857
	Tefki	852	1192	1022	930	1158	1044
	Shashemene	690	821	756	786	938	862
	Inwarie	536	842	689	492	834	663
	Mean	1033	1190	1112	925	1081	1003
South-eastern	Bekoji	1457	1398	1428	1499	1379	1439
	Kulumsa	1374	1322	1348	1145	1068	1107
	Robe	1234	1131	1183	912	990	951
	Mean	1355	1284	1320	1185	1145	1165
North-western	Dabat	1014	1424	1219	754	1050	902
	Debre Tabor	1652	1896	1774	1252	1592	1422
	Motta	1295	1354	1325	1076	911	994
	Burie	1356	1479	1418	773	1096	934
	Mean	1329	1538	1434	964	1162	1063
Western	Shambu	1463	1884	1674	950	1092	1021
Eastern	Wacho	860	902	881	762	718	740

1 = Average of CI-1525 and CI-1652

Table 2. Seed oil content (%) of the improved and local varieties in the linseed national variety trials grown at five sites in two ADZ with 23/23 kg/ha of N and P_2O_5 fertilizer (F_1) or without (F_0), 1984-1986 crop season (7,15,17)

Agricultural Development Zone	Site	VARIETIES					
		Improved			Local		
		F_0	F_1	Mean	F_0	F_1	Mean
Central	Sheno	37.5	37.6	37.6	34.1	34.5	34.3
	Holetta	36.6	36.9	36.8	32.5	32.5	32.5
	Debre Zeit	34.9	35.2	35.1	32.9	33.5	33.2
	Mean	36.3	36.5	36.5	33.2	33.5	33.3
South-eastern	Bekoji	35.3	35.4	35.4	33.2	32.9	33.1
	Kulumsa	35.4	34.9	35.2	33.2	32.8	33.0
	Mean	35.4	35.2	35.3	33.2	32.9	33.1

Table 3. Weight per 1000 seed (g) of the improved and local varieties in the linseed national variety trials grown at five sites in two ADZ with 23/23 kg/ha of N and P_2O_5 fertilizer (F_1), or with out (F_0) 1984-1986 crop season (7,15,17)

Agricultural Development Zone	Site	VARIETIES					
		Improved			Local		
		F_0	F_1	Mean	F_0	F_1	Mean
Central	Sheno	5.9	6.4	6.2	4.6	3.8	4.2
	Holetta	5.6	5.6	5.6	3.3	3.2	3.3
	Debre Zeit	5.1	4.9	5.0	4.0	3.9	4.0
	Mean	5.5	5.6	5.6	4.0	3.6	3.8
South-eastern	Bekoji	6.4	6.3	6.4	5.9	4.3	5.1
	Kulumsa	5.9	5.6	5.8	4.8	4.5	4.7
	Mean	6.2	6.0	6.1	5.4	4.4	4.9

Table 4. Number of days to maturity of the improved and local varieties in the linseed national and extension variety trials grown at 16 sites in five ADZ with 23/23 kg/ha of N and P_2O_5 (F_1) or without (F_0) 1984-1986 crop season. (7, 15, 17)

Agricultural Development Zone*	VARIETIES					
	Improved			Local		
	F_0	F_1	Mean	F_0	F_1	Mean
Central (7)	139	137	138	135	132	134
South-eastern (3)	155	156	156	141	139	140
North-western (4)	137	136	137	138	137	138
Western (1)	145	142	144	134	131	133
Eastern (1)	127	131	129	110	111	111
Mean (16)	141	140	141	132	130	131

* Number of sites in parenthesis.

Table 5. Plant height (cm) of the improved and local varieties in the linseed national and extension variety trials grown at 16 sites in five ADZ with 23/23 kg/ha of N and P_2O_5 (F_1) or without (F_0), 1984-1986 crop season (7,15,17)

Agricultural Development Zone*	VARIETIES					
	Improved			Local		
	F_0	F_1	Mean	F_0	F_1	Mean
Central (7)	70	75	73	52	60	56
South-eastern (3)	80	83	82	74	73	74
North-western (4)	75	79	77	58	67	63
Western (1)	75	77	76	47	56	52
Eastern (1)	85	90	88	55	67	61
Mean (16)	77	81	79	57	65	61

* Number of sites in parenthesis.

Single plant selections were made in the national and international nurseries to capture within plot variation and uniform lines were produced (8). A number of lines is being advanced through a stage of hierarchy of yield trials.

The major effort in the crossing program has been towards incorporating earliness, wilt resistance and low lodging characters in high yielding linseed cultivars. Work on linseed hybridization at Holetta was initiated in 1981. Since then, numerous crosses have been made between high yielding parents and lines with the desired characters (8). So far, no superior varieties have been released from the hybridization program. However, promising ones have been advanced to the national variety trial.

Agronomy

A number of agronomic experiments has been undertaken in various research centers on linseed to identify responses of linseed varieties to various levels of management practices. The main results can be highlighted as follows:

It has been realized that seed improvement implies better cleaning of the seed in addition to the cultivation of uniform, high yielding varieties. Cleaning the seed for sowing, combined with one weeding resulted in a 13% higher yield than the uncleaned seed with one weeding (Table 6).

Table 6. Seed yield (kg/ha) of local linseed variety under different purity levels and weeding intensities, Kulumsa 1968 (3).

Purity	Weeding Once	Weeding twice	Mean
Market seed	870	1110	990
Clean seed	980	1150	1065
Mean	925	1130	1028

Seed dressing is often recommended since linseed is fragile and cracked seeds are very susceptible to fungal diseases during germination (19). At Kulumsa, the plant population of linseed was increased by 12% by treating the seed against seed borne diseases. However, it had no effect on seed yield (4).

In Ethiopia, linseed is often planted in poorly prepared seed beds which result in low seed yields. The seed bed should be firm with small lumps, and must be free of weeds.

Since linseed is often grown in agriculturally marginal areas, relationships between rainfall, time of sowing and weeding frequency are very important in achieving an optimum yield (12). Based on date of sowing trials, mid June to early July has been recommended as an optimum time depending on the soil type (Table 7).

Small holders' linseed landraces are invariably broadcast at a rate varying from 4 to 75 kg/ha (19,21). On-station seed-rate experiments showed that relatively small yield difference to wide range of seeding rates. Seeding rate of 25-35 kg/ha for drilling and 30-50 kg/ha for broadcast are recommended as the optimal (9). In general, 10-20% higher rates ought to be considered in areas where moisture supplies are higher (water-logged conditions) or where weeds may be a problem. Satisfactory yields of linseed can be obtained by broadcasting (Table 8), but sowing in rows is better for ease of weeding and harvesting. At Kulumsa, close row spacing of 19 cm produced higher mean seed yields than the wider row spacing of 38 cm when a seed rate of 25 and 50 kg/ha was used (Table 9).

Linseed is adapted to nutrient deficient conditions and it usually responds poorly to the application of fertilizer under low standard of husbandry. However, there are indications of location by fertilizer interactions. The application of fertilizers particularly nitrogen was important in water logged soils or where moisture supplies are high (9). The slight response in the national variety trials can justify the application of the lowest level of

Table 7. Results of linseed sowing date trials conducted at Kulumsa, Holetta and Ghinchi in different years (3,4,9,14)

Sowing date	Mean seed yield, (kg/ha) of soil								
	Red				Alluvial	Black			
	Kulumsa		Holetta		Illala	Holetta		Ghinch	
	1968	1969	1967	1970-71	1981	1967	1970-71	1974	1975
Early June	-*	-	575	-	-	940	-	-	-
Mid June	-	-	-	1251	655	-	1125	-	-
Late June	-	1393	948	1135	708	1006	1174	360	-
Early July	1090	1057	-	1164	727	-	1324	310	995
Mid July	841	-	920	966	341	1075	1269	150	830
Late July	808	673	734	-	-	717	-	-	-
Mid August	-	-	352	-	-	740	-	-	-
Late August	-	-	130	-	-	255	-	-	-
Mean	913	1041	610	1129	608	788	1223	273	913

* Information not available.

Table 8. Effect of hand weeding in broadcast and drilled linseed, Kulumsa 1968 and 1969 (3,4)

Sowing method	Seed yield, kg/ha							
	Frequency of hand weeding							
	0		Once		Twice		Mean	
	1968	1969	1968	1969	1968	1969	1968	1969
Broadcast	-*	160	810	630	1010	720	910	503
Drill	-	130	990	640	1070	610	1030	460
Mean	-	145	900	635	1040	665	970	482

* Information not available.

Table 9. Effect of row spacing and seed rate on seed yield of linseed at Kulumsa, 1967 season (2).

Seed rate (Kg/ha)	Seed yield kg/ha		
	Spacing between rows (cm)		
	19	38	Mean
25	1240	1040	1140
50	1260	980	1120
100	1030	1100	1065
Mean	1177	1040	1108

fertilizer (perhaps 23/23 kg/ha of N and P_2O_5) (Table 1).

Linseed is ripe when 90% of the bolls turn brown. Delaying harvest can allow seeds to weather and germination is reduced.

Crop protection

The main aim of cultural practices should be the destruction of weeds.

The seed used by farmers for sowing is an important source of weed infestation. Linseed is a poor competitor with weeds at all growth stages. However, in its late stage, the leafiness and height of the cultivar are important agronomic characters in its competitiveness (19). The average yield loss due to weed competition in linseed under Holetta and Mekele conditions was found to be 62.2 and 53.1%, respectively (22). An early weeding, 21 days after emergence followed by mid-season weeding is the minimum number of weeding necessary. However, if the weed population is low, a single early weeding is the most cost effective. Among the herbicides tested at Holetta, Linuron 50 WP at 1.0-1.5 kg a.i/ha and Metobromuron 50 WP at 2.0 kg a.i/ha as pre-emergence treatments and MCPA 40% at 1.2 kg a.i/ha as post-emergence were found to be effective in linseed. However, large-scale testing of these herbicides is advisable before final recommendation is made (23).

Linseed is used in rotation to prevent disease build up as linseed is immune to diseases that attack cereals. At Holetta, high yields of wheat, barley, teff and rapeseed following linseed, have been obtained (9). Disease in Ethiopia may be serious problem where linseed is grown in high rainfall areas, or where the soil is poorly drained. There are many organisms known to be pathogenic on linseed, nine have been recorded in Ethiopia (Table 10). The main diseases are pasmo, wilt, seedling blight and powdery mildew (6, 20). Warm humid weather favours the spread of pasmo. Crop rotation and burning of infected straw can help control of pasmo (13). With regard to Fussarium wilt, high soil temperature (above 25°C) and low soil moisture generally favour the development of the disease (13). The wilt screening activities have been successful in identifying resistance to wilt. The technique for resistance screening against wilt has been worked out and there are varieties, lines and crosses which appear to have high level of resistance.

Four species of insect pests have been recorded, but only two are economically important (Table 11). These are african bollworm and golden plusia. African bollworm is the most serious insect pest (6,18). The use of Endosulfan 39% E.C. at a rate of 2 l/ha or 3.4 l/ha of DDT 25% E.C. is effective to control the bollworm (13). The following four insecticides are found effective in controlling plusia worms (13).

1)Femitrothion 50% E.C. @1.5-2.0 l/ha
2)Carbaryl 85% WP @1.5 kg/ha
3)Malathion 50% E.C. @2 l/ha
4)DDT 25% E.C. @3-4 l/ha.

Table 10. Diseases of linseed recorded in Ethiopia (20).

Disease	Pathogen	Status
—	*Cladosporium* spp	Unknown
Anthracnose	*Colletotrichum linicolum* Pethyb and Loff	Minor
Wilt	*Fusarium* spp	Major
—	*Helminthosporium sativum Pam.*, King and Bakke	Unknown
Rust	*Melampsora lini* (DC.) Tul.	Minor
Garcia-roda	*Mycosphaerella linorum* (Wollenw)	Unknown
Powdery mildew	*Odium* spp	Major
Seedling blight	*Rhizoctonia solani* Kuchn.	Major
Pasmo	*Septoria linicola (Speg.)* Garassini	Major

Table 11. Insect species recorded on linseed in Ethiopia (18).

Common name	Scientific name	Status
Flea beetle	*Haltica pyritosa* (Erickson)	Minor
Blue bug	*Calidea duodecimpunctata* (Fabricius)	Minor
African bollworm	*Heliothis armigera* (Hubner)	Common
Golden plusia	*Diachrusia orichalcea* (Fabricius)	Sporadic

Verifications

On-station verification

The station verification trials over two years showed convincingly that the released varieties and the production package give good yields (Table 12). This means that by improving the practice the productive capacity of the varieties can be utilized and considerable yield can be obtained.

Table 12. Summary of seed yield in kg/ha of the released varieties in the linseed station verification trials grown at two research sites in two ADZ 1985-1987 (Unpublished)

Variety	Holetta Research Center (Central) 3 years	Adet Research Center (North-western 1 year)
CI-1525	1378	1800
CI-1652	1345	2140
Mean	1362	1970

On-farm trials

The on-farm trials are designed to verify and check performance and acceptability of research recommendations. This activity was carried outside of research centers on representative farmers' field. From the surveys, it was found out that most farmers do not weed at all and those who do, make one or seldom two hand weeding when convenient. Certainly, in Ethiopia the crop is broadcast at varying seed rate without fertilizer. Hence, the linseed on-farm trials were conducted comparing the recommended varieties, fertilizer, weeding and seed rate combination with the farmers methods mentioned above. In general, the optimum package gave substantial yield increase over farmers' practice. Management is very critical (1,12). Across locations, both the local and improved varieties gave higher yields where the improved technologies were properly implemented as compared to the traditionally managed fields (Table 13).

Table 13. Mean seed yield in kg/ha of two released and one local variety in the linseed on-farm trials grown at three ADZ using farmers' method and researcher's package, 1985-1987 (1,16)

Agricultural Development Zone	Number of sites	Farmers' method			Researcher's package		
		CI-1525	CI-1652	Local	CI-1525	CI-1652	Local
Central	20	738	748	658	982	974	894
North western	18	457	483	357	680	740	523
Mean	38	598	616	508	831	857	709

Production demonstration

Linseed had been shown to give high yield under pilot-cum-demonstrations. On such 1/2 ha demonstration, 700 kg/ha was a common figure (Table 14).

Table 14. Seed yield in kg/ha of linseed varieties grown in production at three locations in two ADZ 1987-1988 (Unpublished)

Zone	Site	Management		Advantage (kg/ha)	Increase (%)
		Local	Improved		
Central	Arbi Gebeya	430	730	300	69.8
South eastern	Digelu	470	720	250	53.2
	Gonde	-	790	-	-

Conclusion

Great strides have been made in linseed research since the birth of the oilseed improvement program. Marked increases in yield of linseed were achieved by applying a package of recommendations including superior varieties, optimal doses of fertilizer and timely sowing and weeding. One weeding can raise the yield from a complete uneconomical level to a considerable better return. On the other hand, several trials demonstrated that linseed is definitely the choice for poor soils. In future, more emphasis will be placed on popularizing the improved production technology to farmers through a large number of pilot-cum-production demonstrations in farmers' field and through training programs.

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INVESTIGATIONS ON SOME BIOCHEMICAL CHARACTERISTICS OF NIGER SEEDS (*Guizotia abyssinica* Cass)

Getinet Alemaw and Hiruy Belayneh

Abstract

Dehulling technique for niger seeds was developed. The proportion of hull and embryo was about 30% and 70% with a range of 13-36% and 63-86% respectively. Higher oil was associated with larger seed size and embryo proportion. Hull percent showed a strong negative influence on oil content.

Introduction

Niger or noug (*Guizotia abyssinica* Cass) is one of the major oilseed crops in Ethiopia. It is grown in mid and high-altitudes on heavy, poorly drained soils (5). It provides about 50-60% of the country's edible oil. However, the seed yield and oil content are very low.

In sunflower, the increase in oil content was achieved through decreasing the thickness of seed coat or increasing the embryo size (3). In safflower, oil content was found to be inversely related with hull percent (4). Niger, safflower and sunflower have similarities in that they all belong to the family *Compositae*.

Investigations on some of the seed morphology and quality parameters and understanding their relationship would help in indirect selection for oil and improved meal quality. Thus, this experiment was designed:

1) to develop a technique to separate the seed coat (hull) and embryo from niger seeds,

2) to determine the oil, protein and crude fibre contents as well as weight of seed parts of the selected niger genotypes and investigate the inter-relationship among these parameters, and

3) to identify factors which would be useful for screening breeding materials for high oil and protein contents.

Materials and Methods

In 1987, 25 niger accessions selected from 1986 micro, pre-national and national variety trials grown at Holetta were included. In 1987, the study was made on two sets of genotypes which were either high or low in oil content. The two types were identified from the medium-and early-maturing landraces tested in 1987 at Holetta and Debre Zeit, respectively. Holetta and Debre Zeit, are at altitudes of 2380 and 1900 meters, respectively. The inclusion of high and low oil materials was to see the association of this trait with hull characteristics within medium and early maturing ecotypes grown at high and low altitude sites, respectively.

For dehulling, seeds were soaked with water in petridish containing filter papers and were kept in an incubator at temperature of 25 to 30°C for 24 hours. Following this the seeds were oven dried at 75 to 80°C for 24 hours to obtain expanded fibrous hull and shrivelled embryo without any weight loss. For each genotype 20 randomly selected seeds from oven dried samples were carefully separated into seed coat and embryo using sharp needle.

Each fraction was weighed, and hull percent (HP) and embryo percent (EP) were calculated as the ratio of hull and embryo weight expressed as percent of the total seed weight (TSW) respectively. Oil content was determined using wide line magnetic resonance spectrometre (2). Crude fibre and protein contents were determined using acid base digest and the method of Micro Kjeldhal respectively (1). ANOVA was computed for TSW, EP and HP considering the 20 single seeds as replications. Protein, oil and crude fibre determinations were made on three samples from each accessions. A conversion factor of 6.25 was used for protein content.

Results and Discussion

There are significant differences in all characteristics between the genotypes studied in 1987. As shown in Table 1, these genotypes exhibited wide variability in almost all parameters.

Table 1. Mean total seed weight (TSW) hull percent, embryo percent, oil, protein and crude fibre contents of 25 niger populations grown at Holetta in 1986.

Genotype Acc. No.	TSW (mg)	Hull (%)	Embryo (%)	Oil (%)*	Protein (%)**	Crude Fibre (%)**
015584	2.8	13.5	86.5	38.3	27.5	23.4
200426	4.6	18.4	81.5	38.6	28.6	21.2
015585	4.1	18.8	81.2	38.5	27.8	22.6
015506	3.8	19.7	80.3	38.5	26.0	20.6
202235	3.1	20.0	80.0	39.6	26.2	20.9
207399	3.8	20.0	79.8	39.9	23.9	19.3
16650	3.9	20.4	79.6	38.4	26.1	21.2
015504	3.5	21.2	78.8	38.7	23.3	21.9
Sendafa	4.7	21.4	78.6	38.3	28.1	21.3
15637	4.1	25.5	77.5	38.2	28.6	21.9
207403	4.9	23.5	76.5	39.5	23.3	18.0
203187	4.0	24.4	76.5	39.5	23.7	22.3
208425	4.3	25.2	74.8	40.1	23.1	20.7
207400	4.9	25.2	74.8	39.9	23.3	20.3
208402	3.6	25.8	74.2	39.5	23.0	21.0
203182	4.1	27.7	72.3	40.3	22.7	20.7
IAR/Gu/337	5.9	27.6	72.4	38.8	26.9	22.7
203199	4.1	29.9	70.1	39.3	24.5	20.3
203194	3.5	30.1	69.9	39.3	23.3	21.0
203165	5.5	31.6	68.4	39.9	23.4	22.3
203191	6.1	34.8	65.2	39.8	22.8	22.7
Holetta local	6.3	30.3	69.7	38.3	28.3	20.7
208942	6.4	34.1	65.9	38.8	23.9	19.0
208387	7.6	36.7	63.3	40.1	23.4	19.7
203390	7.9	36.6	63.4	39.0	23.1	19.0
Mean	4.8	25.6	74.4	39.2	24.9	20.9
LSD 5%	0.4	3.6	3.0	0.2	1.2	0.4
CV%	14.4	19.0	7.7	0.8	7.6	8.8

* NMR reading of oven-dried seed.

** Analysis based on oven-dried meal.

Increase in EP was accompanied by an increase in protein and a decrease in hull percent. The relationship between oil content and total seed weight, embryo percent and hull percent was not clear because of the narrow range of oil content. This could be because of the materials were under high selection pressure for a higher oil.

There appeared to be genotype-parameter interaction in this study. The genotypes PGRC/E 015506, 015585, 200426 and Sendafa which had high embryo and low hull proportions but relatively low oil and quite high protein. Accessions 207399, 203187, and 015504 had low hull, high embryo proportions and high oil content. These relationships indicate that thin hull results in higher embryo proportion which in turn results either in higher oil or protein content as well as low crude fibre.

In 1988, early and medium maturing types were included (Table 2). Increase in oil content was associated with a decrease in hull thickness and an increase in embryo proportion, confirming that larger embryo results in more oil.

The correlation coefficients among total seed weight, oil and protein contents, hull and embryo percents are shown in Table 3. Total seed weight was negatively related with hull thickness and positively, with embryo proportion. Oil content was negatively related with hull thickness and protein content. Embryo percent was negatively associated with hull percent and positively, with oil content indicating that thin-hull seeds have larger embryo size. The positive relationship of embryo proportion and oil content shows that most of the oil is deposited in the embryo. Hull percent was positively associated with crude fibre and negatively with embryo percent showing that thick hulled seeds have more crude fibre than thin hulled seeds.

As it has been observed in sunflower and safflower (3,4), thinner seed coat or hull in niger seed results in larger embryo proportion that can produce more oil and quality meal as a by-product.

Table 2. Mean total seed weight, hull percent, embryo percent, oil and protein content of three lowland and six highland types of niger grown at Debre Zeit and Holetta respectively, in 1988.

Genotype Acc. No.	Total seed weight (mg)	Hull (%)	Embryo (%)	Oil[1] (%)	Protein[2] (%)	Crude[2] fibre (%)
Lowland (Bunigne) Niger						
202470	3.8	32.1	67.9	25.3	29.6	31.5
202236	5.0	29.6	70.4	30.6	29.1	30.5
15771	5.3	30.2	69.8	31.2	33.1	28.1
Highland (Abat) Niger						
15599	3.3	31.7	68.3	33.6	19.7	26.5
207408	4.0	31.0	69.0	34.5	27.7	26.5
200425	4.5	24.4	75.6	38.0	27.9	25.5
202459	4.3	28.3	71.6	38.8	27.7	26.0
15761	3.3	27.8	72.2	39.2	28.1	25.5
202237	4.7	25.5	74.5	39.3	29.0	25.5
Mean	4.3	28.9	71.0	34.5	28.0	27.2
LSD 5%	0.1	2.9	3.8	2.1	3.6	1.4
CV %	2.1	23.3	12.2	4.7	3.2	11.4

1 - NMR reading of oven dried seed.

2 - Based on defated dry meal.

Table 3. Correlation coefficients among some physico-chemical characteristics of 9 niger accessions grown at Holetta and Debre Zeit, Ethiopia in 1988.

Character	Hull percent	Embryo percent	Oil content	Protein content	Crude fibre
Total seed weight	-0.28	0.29	-0.01	0.59	0.08
Hull percent		-0.99**	-0.76*	-0.22	0.62*
Embryo percent			0.75*	0.23	-0.61*
Oil content				-0.15	-0.50
Protein content					-0.31

* Significant at 5% probability level.

** Significant at 1% probability level.

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PROCESSING OF OIL SEEDS IN ETHIOPIA

Dejene Tezera

In Ethiopia nigerseed, cottonseed, linseed, groundnut and rapeseed are mechanically pressed in 12 oil mills with total capacity of approximately 315 tons/day to residual oil content of 7-15%. The residue (oil cakes) are then collected and extracted with n-hexane to the oil content of $\leq$ 1%, at Modjo Solvent Extraction Plant with a capacity of 200 tons/day, Table 1.

The meal is dissolventized and used as animal feed where as the oil is refined, bleached and deodorized to be used for human consumption Table 2.

Table 1. Oil seeds processed in the factory under Ethiopian Food Corporation (tons)

	Year			
Type of Seed	1984-85	1985-86	1986-87	1987-88
Nigerseed	10882	6875	15352	4795
Linseed	3746	10035	7003	4949
Cottonseed	34421	45175	49375	54342
Papperseed	12241	15478	14421	9946
Groundnut	3200	11715	2272	1502
Total	64490	89278	88423	75034

Table 2. Products and by-products of oil mills (tons) under EFCOR 1984-87

	Year			
Product	1984-85	1985-86	1986-87	1987-88
Cake	30669	55777	70836	61641
Oil	11874	15393	17503	12843

Screw Pressing

In screw pressing process, the oil seeds after preparation, i.e., size reduction and heat treatment, are subjected to high pressure pressing for efficient separation of oil from oilseeds, Figure 1.

The first step in the preparation of seeds is the mechanical treatment like cleaning of foreign matters (stems, sticks, leaves, sand etc.). Tramp irons are also separated from the seeds using permanent and/or electro-magnet. Hulls from oilseeds like cottonseed and peanut are also removed in this section and used as household fuel.

For efficient separation of oil from oilseeds the seed is reduced to smaller size using roller mills. The next important step in the preparation of oilseeds is cooking. The primary objective of cooking is:

a) to coagulate the proteins in the seed causing coalescence of oil droplets and making the seeds permeable to the flow of oil.

b) to dry the seeds to give the seed mass proper plasticity for efficient pressing.

c) Insolublization of phosphatides.

d) Destruction of mold and bacteria.

In most of our oil mills, we have 3 stock cookers. As the top level of the cooker the moisture is brought to 12-15% and the temperature is rapidly increased to 88^{0} C (195 ^{0}F) to deactivate the enzyme system and prevent Free Fatty Acid (FFA) rise during cooking, and at the final stage indirect heating reduces the moisture content to 3-5%.

Extraction by screw pressing is done as straight pressing. In some of the newly established and efficient mills the oil content is reduced 6-7% but most other plants leave as much as 15% oil in the oil cakes.

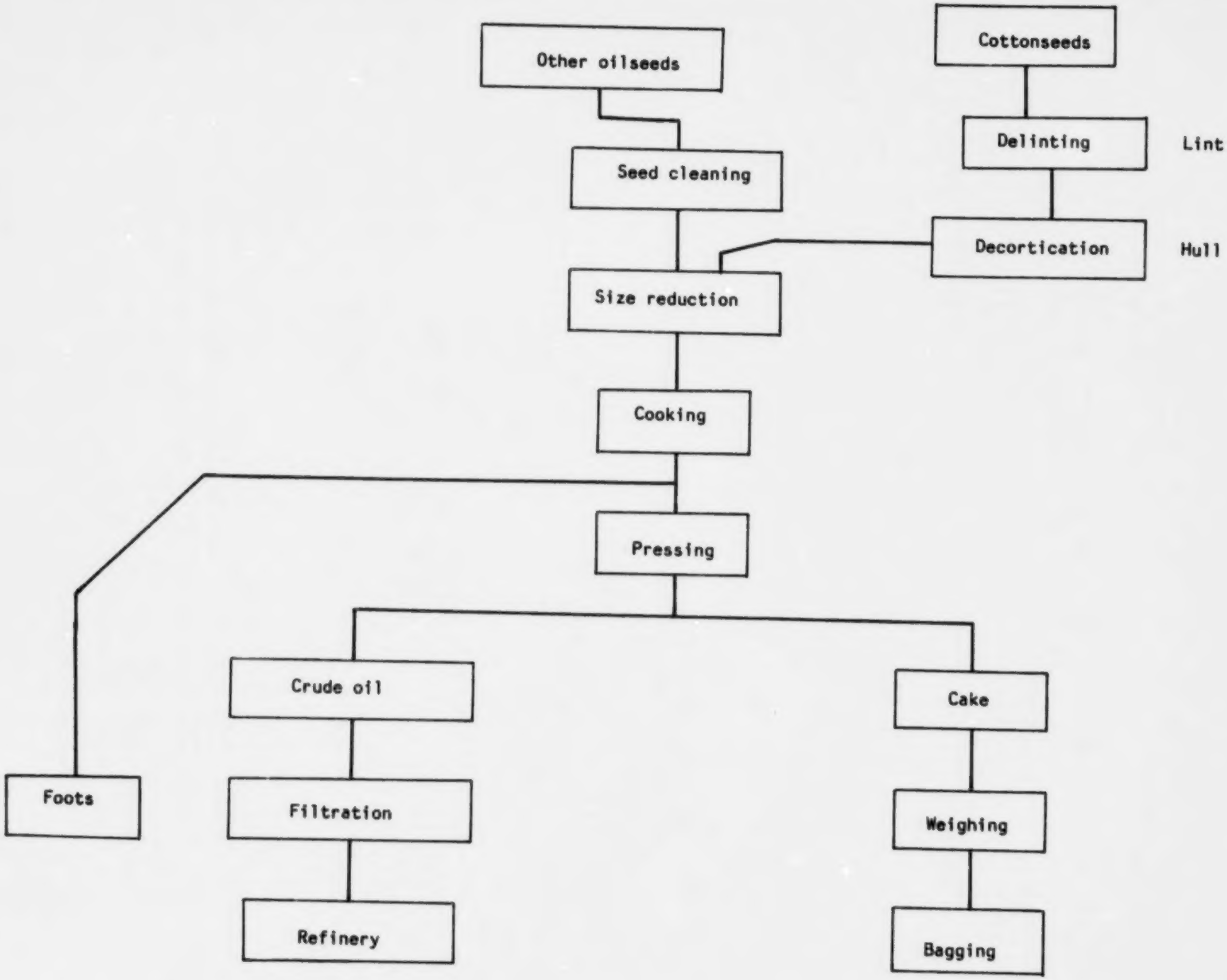
Other oilseeds
Cottonseeds
Delinting
Lint
Seed cleaning
Decortication
Hull
Size reduction
Cooking
Pressing
Crude oil
Cake
Foots
Filtration
Weighing
Refinery
Bagging

Fig. 1. Flow Diagram of Screw Pressing (typical for EFCOR factories).

Continuous Solvent Extraction

Solvent extraction is the most efficient method for recovery of oil from any oil-bearing material and in addition, it is relatively the most advantageous in the processing of seeds or other raw materials low in oil content. The advantages of solvent extraction is that the extracted cake (meal) is fat free and the proteins are not denatured.

Besides the fat free residue (meal) obtained by solvent extraction, the yield, which is the primary purpose, is improved and the proteins in the meal are not denatured.

Oil cakes from all screw press plants, under Ethiopian Food Corporation are transported to Modjo. The raw materials (cake) containing 7-15% oil are broken to smaller pieces by cake breaker, milled to the desired particle size, weighted and fed in an even stream into a continuous solvent extraction plant. A special feeding device simultaneously acting as a gas lock feeds the raw material to the carousel extraction and here counter current percolation extraction is carried out using n-hexane as solvent, Figure 2.

The rich miscela (15-30%) oil leaving the extraction is pumped to the distillation section where the solvent is distilled off in three stages under vacuum. There, in the 1st stage of distillation, solvent vapours are used to heat the miscela. The crude oil, after distillation is cooled and conveyed to refining section.

The oil free meal containing less than 1% oil and bound solvent of 40-200% is freed from bound solvent in the desolventizer-toaster drier, and is simultaneously thermally conditioned (toasted), dried, and cooled. Most of the latent heat contained in the vapours from desolventizer is used in the miscela concentration process.

The toasted, dried meal is pelletized and used as animal feed. The solvent from miscela distillation and remaining desolventizer vapours are fed to three different water-cooled condensers. The condensate is piped to solvent water separator based on the principle of "florence flask". The solvent is recycled to the extractor thereby closing the solvent circuit. High efficiency recovery of solvent from waste gas (air) is carried out by absorption in mineral oil.

Refining

Crude oil produced by expression or solvent extraction besides triglycerides contain non-glyceride components (impurities). Principally these impurities are FFA, and in lesser amounts phosphatides, sterols, tocopherols, hydrocarbons, pigments, gossypol (in cottonseed), chlorophyll, protein fragments, etc are found. The objective of refining is to remove these unnecessary impurities from the oil with the minimum possible loss of oil.

In all screw plants of EFCOR, we have batch-type refining with a capacity from 30 quintals to 10 tons per batch. In the solvent extraction plant of Modjo, we have a continuous neutralization plant with a capacity of 30 tons per day. In both refining methods, batch and continuous chemical refining (neutralization) is the 1st step. In the neutralization process, after determination of FFA percent in the laboratory, appropriate quantity of caustic soda (NaOH) is mixed with oil and the soap stock formed is settled by gravity in the batch type or centrifuged in the case of continuous neutralization. The neutralized oil is washed with hot

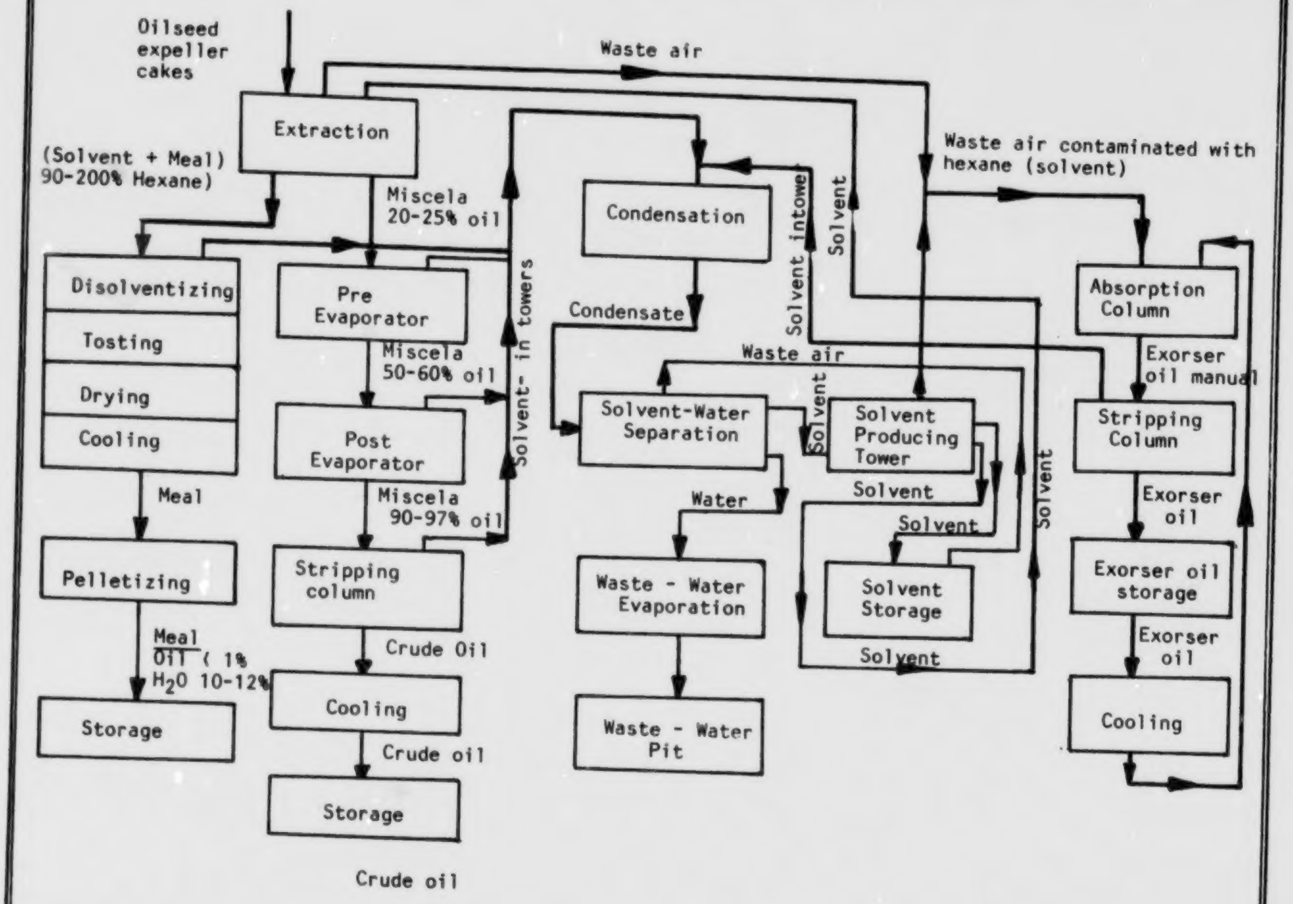
Oilseed expeller cakes
Extraction
Waste air
(Solvent + Meal) 90-200% Hexane)
Miscela 20-25% oil
Disolventizing
Tosting
Drying
Cooling
Meal
Pelletizing
Meal
Oil (1%
H_2O 10-12%
Storage
Pre Evaporator
Miscela 50-60% oil
Post Evaporator
Miscela 90-97% oil
Stripping column
Crude Oil
Cooling
Crude oil
Storage
Crude oil
Solvent- in towers
Condensation
Condensate
Solvent-Water Separation
Water
Waste - Water Evaporation
Waste - Water Pit
Solvent intowe
Solvent
Waste air
Solvent
Solvent Producing Tower
Solvent
Solvent
Solvent Storage
Solvent
Solvent
Waste air contaminated with hexane (solvent)
Absorption Column
Exorser oil manual
Stripping Column
Exorser oil
Exorser oil storage
Exorser oil
Cooling

Fig. 2. Block Flow Diagram of Solvent Extraction Process in Modjo Solvent Extraction & Oil Refining Plant.

(90°C) water, 10-20% to the weight of the oil. The soapy water is then settled or centrifuged. This is done two times successively. The washed oil is then dried and bleached to the desired color using bleaching earth. The bleached oil is then deodorized to remove the odiferous oxidation products of triglycerides (ketones, aldehydes, peroxides etc.) at the temperature of 180°C and nearly absolute vacuum.

The oil is sold bottled in one litre bottles or in a barrel.

THE STATUS OF LINSEED, SAFFLOWER AND NIGER RESEARCH AND PRODUCTION IN KENYA

T.C. Riungu

Kenya is a developing country which is largely dependent on agriculture for its economy. The agricultural production is based on the 25% of the country's landmass. The remaining 75% is semi-arid or arid and has low, erratic and unreliable rainfall. Hence, it is marginally usable. However, due to population growth, human settlement and crop production are moving to these areas.

Agriculture is the major foreign exchange source. In 1985, the sector accounted for 31% of the gross domestic product and generated 63% of export earnings.

The per capita consumption of oil and fat in Kenya has risen from 1 kg in 1970 to 5 kg in 1986 and the rise is estimated to be 6 kg by the year 2000. The rise has been influenced by population growth, urbanization, change in eating habits and increase in per capita incomes.

According to the latest available statistics and annual consumption stands at 140,000 mt and this is expected to rise to 220,000 mt by the year 2000. The local commercial production is estimated to about 20,000 mt; the deficit is met by importation, using the limited foreign exchange earnings.

Only small quantities of oil crops are produced because the oilcrops have not been promoted to the extent of other crops. Development has been hampered by poor marketing structure and hence farmers find it unprofitable to grow. This has been aggravated by external forces caused by developed nations that subsidize their produce and therefore make it cheaper and attractive to local processor. Kenya has, hence, continued to rely heavily on importation of vegetable oils making it the single highest item in Kenya's food import bill (ksh. 1.2 billion annually).

Faced with the present situation of increasing demand, accompanied by limited foreign exchange for importation, the government of Kenya has outlined a food policy package focussing on achieving self sufficiency, security and import substitution by the year 2,000. This entails among others the expansion and intensification of the oil crop industry.

In Kenya, the wide range in physiography, climate and geographical position provides conducive environment for the production of many oil crops from which commercial oil and protein cake are extractable. Sunflower *(Helianthus annuus)*, rapeseed *(Brassica spp)*, soyabean *(Glycine max)*, sesame *(Sesamum indicum)*, groundnuts *(Arachis hypogea)*, safflower *(Carthamus tinctorius)*, cotton *(Gossypium spp)*, Coconut *(Conus nusfera)*, linseed *(Linum usitatissimum)*, castor *(Ricinus communis)* and niger *(Guizotia abyssinica)* are among the oilseed crops that can be grown in various agro-ecological zones in Kenya. The main oil crops produced are groundnuts (21,060 t), sunflower (17,300 t), castor (6,950 t) soybean (3,982 t), rapeseed (3,620 t) and sesame (3,600 t), 1987 figures. This paper is however, on the status of linseed, safflower and niger research and production in Kenya.

Linseed (flax)

Linseed is an annual oilseed crop grown mainly for the provision of non-edible industrial oil. It is not an indigenous oil crop to Kenya and all the lines/varieties screened, tested and used for commercial production have been introduced.

In Kenya, linseed thrives in cool and wet areas and is well adapted to the altitudes of between 1000 m (3000 ft) to 3000 m (9000 ft)a.s.l. Introduction, screening, evaluation and production as a fibre crop commenced in 1920's but the production disappeared from agricultural scene about 1955-1956. Trials and production of the oil types were started in 1959 and 1962, respectively. By 1976 when the last successful experiments were conducted, 25 lines were under trials. The results over years showed that the lines/varieties performed well. Flowering was found to range between 60 and 80 days while maturity ranged between 115 and 150 days. The seed yield ranged between 580 and 2330 kg/ha. The oil content is between 38 and 41%. The only diseases observed were pasmo, rust and seedling rot.

The field performance data recorded over the years led to the recommendation of 10 lines for commercial production; five of which are shown in Table 1.

Table 1. Mean values of some characters of recommended lines.

Line (variety)	Flowering days	Maturity days	Seed yield (kg/ha)	Oil content %
Linda	72	132	2330	40.0
Linot	71	132	2190	40.0
Norlata	72	131	2120	40.0
Cree	67	134	2020	39.4
Nored	67	134	1800	39.8

Research work that has been carried out by National Plant Breeding Station, Njoro, Kenya and other Kenyan Gov. Research Institutions has shown that linseed can be produced in Kenya. However, currently there is no commercial production. This is mainly due to unstreamlined production and marketing structures. As a result, Kenya has continued to import linseed products.

Conclusion: The past work concentrated on germplasm introduction, screening, evaluation and production. Presently, due to the lack of promotion, production and marketing structures, the on going activities at National Plant Breeding Station are mainly focussing on bulking and maintenance of the available germplasm and released lines. To substitute the importation of linseed products, production and marketing of the crop should be undertaken.

Safflower

Safflower is generally cultivated in the tropics and in the temperate zone. It is an important crop in the traditional farming systems of the semi-arid areas of India, Egypt and other Mediterranean countries where the flowers were used as a source of dye. Today, however, it is exclusively grown as an oil crop.

In Kenya, most of the cash crops such as coffee, tea, pyrethrum, wheat, rapeseed etc., are ecologically restricted to high potential agricultural areas usually found in the highlands. Medium and low potential (arid or semi-arid) agricultural areas rarely have well established crops. Safflower, a drought tolerant crop, can be grown in marginal areas of Kenya where a large part of the country is arid and semi-arid.

Safflower in Kenya has been introduced mainly from Mexico and

USA. It has been screened and preliminarily tested by Kenyan Government Research Institutions and Oil Crop Development, a subsidary of East African Industries (multi-national). The experimental work has shown that safflower can be grown in Kenya. For example, seed yields have been found to range from 500 to 5,000 kg/ha. The average performance, over 3 years, of some lines is as shown in Table 2.

Table 2. Mean values of characters of some genotypes.

Genotype	Days to flowering	Days to maturity	Seed yield (kg/ha)	Oil content %
Ute	98	143	1495	32
Sisen 1550	108	114	741	13
US-10	101	142	1934	31
UFSTP-1	100	134	2097	34
Sisen 1202	120	145	961	30
Oleic leed	108	143	2375	33
Gilla (USA)	106	142	2180	32
Wellington 541	98	137	607	-
Royal 71	111	141	548	21
Wellington	317	99	142	37

Though experimental work is not yet concluded, Oil Crop Development has introduced commercial production of safflower in a few marginal (low potential) areas; namely Naivasha, Gilgil, Masai, Mara and Machakos. The extensive production is, however, yet to be realized.

There are a number of problems that contribute to the hindrance in extensive safflower production. These included:

a) streamlined marketing,
b) diseases, (Alternaria and bud rot),
c) low oil content,
d) spineless on leaves and
e) production package.

Oil Crop Development is looking into marketing constraint while other problems are being addressed by research institutions by screening disease tolerant and high oil content types, developing spineless genotypes and to a lesser extent developing the production package.

Conclusion: Safflower is a potential crop particularly in the marginal areas, and hence the development of varieties, production technologies and marketing structures, though already started, need to be more emphasized.

Niger

Niger has been found to grow in Kenya but no development activities have been undertaken. However, Kenya Seed Company has produced some seed.

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SUMMARY AND WRAP-UP FOR OTHER OILCROPS SUB-NETWORK

Hugh Doggett

Dr. M. V. Rao: in his opening address emphasized that the oilseeds mission directorate has a special interest in the minor oilseed crops being considered by this workshop; linseed, niger, and safflower. These are crops which are adapted to particular niches in Indian agriculture.

India has 45% of the World area of linseed, mainly in Central India. Linseed oil is still used as an edible oil in some places, but it is grown mainly for industrial uses. Good progress has been made in developing dual purpose types, for fibre as well as for oil. Such types have been released, but now need popularization. Another dual purpose type is being sought, the combination of the fibre crop and the low-linolenic grain of the type recently developed in Australia. Linseed is often broadcast into a rice paddy some time before harvest, so that the young plants are established and growing before the rice harvest is taken off. (eg. "Utera" cultivation in Madhya Pradesh).

Perhaps all of the niger crop produced in India is grown by Tribal peoples. There is no substitute for it, no other oilseed can produce under the harsh conditions where niger is grown: it will establish on very dry soils, and grows in most unpromising thin, often rocky soils. It also flourishes in forest clearings. The parasitic weed *cuscuta* is often a problem, difficult to control, difficult to eradicate, a situation parallel to that of *Striga* on cereals. Niger is mainly a subsistence crop, consumed in the areas where it is produced, but some 10,000 mt are exported annually as bird-seed. (Great care is taken to avoid contamination with *Cuscuta* seed).

Dr. Rao stressed that the Network should aim to include all the people involved with these crops, whether producing, processing, or marketing; whether in the Developed or in the Developing World; including producers such as Argentina, the USSR, the USA, Ireland, or other European countries. All producing countries should be involved, or the Network will not function properly. Private and public sectors must be concerned. Germplasm raises particularly important issues - germplasm must be available to all. The Developing World has given, and gives, its germplasm freely: this must be fully reciprocated by the Developed World. "Poor Man's Crops" are in special need of this kind of cooperation.

The technology mission for Oils brought together those activities in 17 different ministries that are related to oils and to oil crops. A start has been made in blending oils: certain combinations have been permitted, and more will follow, permitting oil mixtures with a more balanced nutritional quality to be sold to the public.

Impressive progress has been made during the two-years of the Commission's existence. Last years's oil crop production was good, in spite of poor rains. This year, the crop is expected to reach 15 million tons, three million more than the previous record: it is hoped that 18 million tons will be produced in 1990. A truly multi-disciplinary approach has been adopted, each person with his own role and responsibility.

Mr. Andrew Ker: Thanked Dr. M.V. Rao on behalf of IDRC. He had been very impressed by the standard of farming seen on the tour from the G. B. Pant University around a part of Northern India. India's achievements in food and oilseeds production are the best attainments of any country trying to achieve self-sufficiency.

The Oilseeds Network was begun in the early 1980's and has reached the point where sub-networks of various oil crops are being formed. Safflower, linseed and niger are being considered for the formation of a joint sub-network: safflower has already formed its own advisory and coordinating committee. IDRC is not a large donor agency, and its inputs to the network have been minimal. The sharing of germplasm, planning for collaborative research, and training needs, should all be given full attention. It is proposed that the complete network should have a steering committee.

Dr. Engels: From IBPGR, mentioned briefly the reorganization and redeployment of his Board. Emphasis is being placed on germplasms research that relates to crop plants. Research topics are: i) conservation methodology, ii) utilization, iii) better access for plant breeders, iv) careful study of quarantine problems, v) fostering free germplasm exchange. IBPGR might consider funding research projects in these fields. The IBPGR Regional offices would have their own field programs. Headquarters are located in New Delhi, Beijing, Nairobi, Rome, Singapore and Kew. (The New World was not mentioned). In the past, IBPGR has also given less priority to the "neglected" oilseeds. Their diversity must be preserved. IBPGR would consider a project on the germplasm utilization of these crops, and would welcome advice. Where should the base collections be kept? A global data base is required, and descriptor lists for niger and linseed are needed. IBPGR would support work on any germplasm problems.

Dr. Engels' presentation was good, and he is evidently eager to be as helpful as possible, which we all welcomed. He may not yet have realized quite what a mine field there is in the whole germplasm issue. His first task is to build confidence and to dispel wrong ideas and misgivings. Quite a lot of people in the Developing world suspect that the whole IBPGR exercise is an attempt by the West to get hold of "their " Third World germplasm, to exploit it, and then to make enormous profits by selling the products back to the Third World. There is a major confidence-building exercise required, and it will take time to build up to level of mutual trust required if there is to be free movement of germplasm.

Dr. Ranga Rao: Reported on the Safflower Conference. Sixteen countries were represented by 110 delegates, 45 of whom came from countries other than India. The following were among the principal recommendations:

Pest and disease resistances must be identified: *Alternaria* is especially important.

The development of hybrid safflower must be undertaken.

A steering committee on global genetic resources should be set up, to determine:

a) priority areas for collection b) the base location for the collection c) preparation of a global data base. Dr. Abbas Omran offered to arrange for the re-export of safflower germplasm from Ethiopia.

An international centre for all oilcrops other than groundnuts and soya is needed.

A diagnostic handbook for pests and diseases of safflower should be produced. Neglected research areas should be identified, e.g. safflower physiology. The next safflower conference should be held in China, or failing that, in Australia in 1993.

Dr. Abbas Omran: Presented a brief history of the Network development, followed by a projection of its probable further growth, including the creation of an Oilseeds Research Unit. He then proposed a vote of thanks to Dr. M.V. Rao.

Niger

India

Dr. S.M. Sharma: presented a paper on Niger in India. In 1985-86, 620,000 ha of niger were grown, and produced 190,000 mt of seed: the mean yield was 305 kg/ha. The crop is grown mainly by tribal people on poor soils, with a minimum of care, effort, or expenditure. Seventy-five percent of the harvest is used for oil extraction, mostly for food, though some goes into the perfume industry. Lower grades of oil are used for soap-making and for burning in lamps. Eighteen percent of the seed is used for making chutney. The oil cake is fed to livestock.

The crop is extensively grown on marginal and sub-marginal lands, and grown over a range of rainfalls, 1,000 -1,300mm probably being optimum. Prolonged rain at flowering depresses the activity of the honey-bee pollinators and so reduces yields. The seven available "improved varieties" are either local varieties, or selections out of local varieties. Other selections from similar sources are awaiting release. Timely planting increases yields: fertilizer application of 20:20 kg/ha of NP with half of the N applied at 30 days after planting gives much improved yields. Given a reasonably clean field at planting, niger competes well with weeds. Two weedings are advised, at 15 days after planting, and again (if needed) at the time of nitrogen top-dressing (30 days after planting). Cut-worms, grasshoppers, and a number of caterpillars are recorded as pests. The statement "These may be controlled by appropriate dusts or sprays" tells us nothing about the economics of doing this. Diseases include powdery mildew, *Alternaria* and *Cercospora* leaf spots. Seed-dressing with Thiram is recommended.

The future development of the niger crop depends firstly on breeding varieties that respond well to inputs and good management, secondly on Cropping Systems Research using such varieties.

Problems of soil management in the hilly tribal areas will take a long time to solve; but improved niger cvs might well extend the areas under the crop, and also might begin to contribute towards the solution of the soil management problems. (The speaker's photographs of some of the areas where niger is growing were very disturbing, and left the viewers with a profound respect for this crop. Is there anywhere it cannot grow?

Dr. A.V. Joshi's paper reported mainly on niger in Maharashtra. Again, released varieties were obtained by selection within local types. Dr. Trivedi is working at Kanki, Bihar, with over 175 germplasm lines maintained by sibbing. He aims to canalize desirable genes into one gene pool. Superior varieties have been identified from Indian germplasm, and a genetic male-sterile has been obtained: this is potentially useful in crossing work, and perhaps for hybrids in due course.

Ethiopia:

Niger breeding in Ethiopia has made good progress: self-compatible (self- fertile) lines have been extracted, and populations developed. Two varieties have been released, yielding 10 q/ha, with 40% oil content. Studies have shown that selection for higher oil content is much assisted by a dehulling technique, the percentage of hull shows a high negative correlation with oil-content, while higher oil-content is associated with larger seed size.

General comments:

I am filled with a great sense of frustration: here we have two excellent, imaginative breeding programs at Kanki in Bihar and Holetta in Ethiopia, yet the main benefit of the Network remains unharvested. We all know that the productivity explosion in the maize crop came from putting together that northern flints and the southern dents. We all know that the productivity explosion in the sorghum crop came from putting together the northern milos and the southern kafirs. This was why the Network was developed: we know that there is a great burst of productivity waiting to be released when we bring together the Ethiopian crop populations with the corresponding Indian crop populations - or is it that we do not understand, or believe in, population genetics? Why after more than eight years have the Ethiopian and the Indian nigers not yet been brought together, when the right kind of programs are just there waiting for them to be put together? Is it an administrative problem, or does not anyone really believe that this will work? I would urge those concerned to get together and make a bilateral agreement to exchange exactly equal numbers of varieties or composites, exactly the same number of seeds if necessary, but to get that exchange done at the earliest possible moment. Then they will begin to get an idea of how big a bonanza they are sitting on at present.

Sunflower was developed as an oilseed crop within the last 150 years: the development of safflower as an oilseed crop is even more recent. These are both close relatives of niger, and this crop may have an even greater potential for development. It at least starts as an oilseed crop, whereas the other two were grown for their flowers or edible seeds.

Niger should be selected under good management and medium to high input levels, to see how productive the crop can be made. I always favour selecting initially under good management, because that exposes differences, then reselecting the material under both good and poor, hard conditions. With a crop such as niger, which can be handled as a composite, such selections can be run as composites with mass selection until F_5 or F_6. The best material should go into cropping systems observations at an early stage.

The tribal peoples are not going to be taught the benefits of good farming and good soil management overnight, that will be a slow process. There is no point in trying to do this until one has crop varieties that respond profitably to the additional work/cash inputs required. While very conscious of the needs of the Tribal's, we must not confine our thinking about niger to that area. Progress in improvement under good farming conditions in Ethiopia is most encouraging. Add in the heterosis which will follow the linking of the Indian and Ethiopian populations, and we shall find that we have an oilseed crop with a potential at least as great as that of sunflower and safflower as well as a crop from which it should be possible to select populations able to be productive under very unpromising conditions of soil and moisture.

Linseed

India

This crop is receiving good attention in India, and has found in Dr. Manga Rai, a scientist determined to exploit the full potential of linseed. India has 14 centres with 32 scientists working on linseed. Other scientists at various universities are also involved in linseed research. The area under the crop is 1.5 million hectares, with productivity averaging some 250 kg/ha, against a world average of 550 kg/ha. The crop is regarded by the Indian farmer as a second grade oil seed crop, so it receives little care and attention. Some 25% of the total area is cultivated on the traditional "Paira" or "Utera" systems which give an average yield of only 100 kg/ha. The oil content of the seed is in the range 35-45 percent. Linseed is a good intercrop, especially when fertilizer is used. Certain crop combinations show interesting effects: intercropped with chick-pea, the infestation with *Heliothis* is much reduced, so this is a profitable crop combination. Lentil and *Lathyrus* are also good intercrops with linseed, as are potatoes. The amount of breeders' seed being released increases every year, and 19 varieties have been developed to match different cropping systems, many of which have good disease resistance levels. Rust, powdery mildew, and *Alternaria* blight are important diseases, and there is a disease race problem. Crop rotation is recommended to minimize wilt (*Fusarium* sp.). A "Bud Fly" (*Desyneura lini*) can be a troublesome pest.

Dual -purpose types have also been developed, combining good fibre (flax) production with good seed yield. Two such varieties have recently been released, "Gaurav" and "Jeevan". More research stations are being upgraded for linseed research under the Seventh 5 -year plan.

Pakistan

In Pakistan, some 10,500 ha of linseed are grown, producing 5,600 mt of seed, an average yield of 533 kg/ha. The crop is generally grown as a mixed crop with field peas, rapeseed/mustard, and wheat. As a sole crop, it often follows rice, mostly without irrigation. Given irrigation and optimum inputs, seed yields up to 2,800 kg/ha are obtainable. Little breeding work has been done: L-1 is the only variety grown commercially. A slightly earlier variety, Pr-2/4, with a higher yield potential, is about to be released.

Ethiopia

Linseed occupies some 105,000 ha, and is widely grown in the highlands. The mean yield is about 360 kg/ha. The crop may be grown as a sole crop on marginal and submarginal lands. As with many oilcrops, the local practice has been to leave oil crops to the end of the rotation, and to keep inputs of all kinds to an absolute minimum. Local varieties are landraces, but the introduction of material from France and Ireland together with a hybridization program has resulted in the release of four high-yielding exotic varieties. There is good material in the pipeline from the hybridization program. Earliness, wilt resistance, and little lodging are major breeding objectives. Powdery mildew, seedling blight, pasmo and fusarium wilt are important diseases: *Heliothis* is a common pest, golden Plusia a sporadic one. Oil contents have been improved by some 2 to 3 %, while yields have been improved by some 10 to 40% depending on location. Better varieties, supported by improved agronomy, with a good series of farmers' trials, are contributing to steadily improving yields.

Safflower

This has been dealt with in a separate conference. I would only note the progress being made in India on developing spineless varieties, and the fact that China already has such types. I believe that further progress along such lines is desirable before serious attention is given to the spread of safflower into Africa.

General Comments

Germplasm

I would stress my comments made above, under niger. There is a great need to put together the Indian germplasm and the African germplasm of all these crops. They have been separated for 2,000 years or longer. It is really important that appropriate bilateral agreements for the exchange of germplasm should be made as soon as possible. There will be no "one-way" benefits: each country needs the germplasm of the other to produce populations that will yield excellent new material to knowledgeable, dedicated and diligent plant scientists. There is a great willingness on the part of IBPGR to help, and more exploratory discussions should be going on, at least about where and what needs to be collected.

Oil crop improvement

One noticeable characteristic of the crops we have been considering is the way that farmers have treated them in traditional agriculture as crops to be planted and left to grow as best they may. This is a tribute to their capacity to grow on impoverished land with little care. However, there is every indication that given carefully bred varieties and good agronomy, we can expect to see very substantial advances in production during the coming decade or two. I am particularly glad to see the increasing attention being given to On-Farm trials; those were missing in the early days, the farmer had no real input to the research work. I am sure that much faster progress will follow the widespread adoption of this approach.

Oil extraction

It is important to increase the productivity of the oilseed crops: but it is also important to increase the amount of oil extracted, so that even more oil is obtained from each unit area of land under crop. One item in the Ethiopian presentation described comparatively small solvent extraction plant which was being used to extract more of the oil from the cake remaining after crushing by local village methods. This draws attention to Dr. Mangla Rai's opening speech - the shortfall in India's edible oil requirements could be fully met if only all the oil could be extracted from the oilseeds already produced each year. More attention should be paid to extracting more oil from the existing oilseeds harvest. The economics of using a solvent extraction plant to mop up more of the oil left in the cake by the village extraction machines deserves study.

Oil Crops Research Unit (ORU)

The Steering Committee for the Network will be considering the possibility of developing a Unit to provide some basic research for oilcrops which are receiving but little as yet. My impression, re-enforced by these meetings, has been that backup research on sesame, niger, and linsaed is relatively less than on other oilseeds, and that these crops are most in need of attention.

OTHER OILCROPS SUBNETWORK

DISCUSSIONS AND RECOMMENDATIONS

A. Discussions

Safflower

Khalique - How is safflower seed processed in India? Because of the spiny nature of the crop, is it not difficult to harvest?

Ranga Rao - The large mills are not permitted to process safflower, so that the seed will be used locally and about 80% of the production is processed in the local village/ghani. These ghanis process about 40kg of seed per hour. The cake contains about 10% of oil and is used both as a fertilizer and feed for livestock.

The spines are not a problem to those who become famīliar with the crop. Traditional farmers do not go into the fields after flowering and at maturity; the lower one - third of the plant is free of spines. Thus, the farmer can start harvesting at one side of the field and pile the cut or pull plants in a pile for later threshing with a tractor or frail. The spines are a psycological barrier for the non-traditional farmer thus spineless varieties with a yield potential of 75-80% of the normal are being developed for such situations. We are optimistic that we can further raise the yield of the spineless types.

Wang - How long has safflower been grown in India?

Ranga Rao - It is believed that safflower production goes back to very ancient times when the petals were used for dying purposes. However, it has not been grown for dye purposes for at least the last 60 to 70 years. It is now grown exclusively for oil in India.

Chaudhry - To what extent are the spineless types grown in India? What is the oil content of Indian varieties?

Ranga Rao - There is no commercial production but one adopted variety is in the pipeline. The oil content of Indian varieties is about 30 to 34% and the spineless types contain about 31-32%. The level of oil in Indian varieties is lower than varieties grown in other producing countries.

Debela - What is the maturity range within the Indian varieties?

Ranga Rao - The length of the growing season varies widely for the same variety, depending on where it is being grown. In the north the crop takes up to 180 days while the same variety grown in the south will take only 110 to 125 days.

Wang - What area is sown to your spineless selection?

Sawant - The spineless varieties are just now being introduced.

Ranga Rao - What is the correlation between the spineless characteristic and yield?

Sawant - Of course at the present time, the correlation would be very high but there is no known reason why the spineless trait cannot be combined with high seed and oil yields but it will take time to combine all the desirable traits.

Linseed

Chaudhry - When you intercrop linseed and gram, will there not be a problem as both are susceptible to wilt? Is there a solution? Chickpeas are also susceptible.

Mangala Rai - We have not encountered a serious problem in this regard. Perhaps there are root exudates which give cross control or other factors such as the preceding crops which limit wilt. We will demonstrate this intercrop system at 140 locations this year.

Rana - What is the oil content of the yellow seeded line LC145?

Mangala Rai - About 46%. It has the highest oil content of all the present varieties.

Downey - Why do you think yellow seeded forms of flax have not become established commercially since they are higher in oil and look nicer than brown seeded forms?

Mangala Rai - Perhaps they are lower in yield.

Downey - We find the yellow seeded varieties of *Brassica juncea* are consistently higher yielding than brown seeded forms. It has also been found in North America that yellow seeds tend to crack or break in handling more than brown seeds, because of their thinner seed coat. However, no such problem has been found in yellow seeded *B. juncea* or *B. campestris*.

Nigerseed

Engels - In the maintaining of niger germplasm, is manual or sib pollination being employed rather than just bagging adjacent plants in the row? The self incompatible nature of niger would not result in much seed if manual sibbing is not done.

Sharma - You are correct. Manual sibbing under the pollen bags is used.

Hadjichristodoulou - It was indicated that niger is grown in areas receiving upto one meter rainfall and yet you indicated that the crop is grown because of its drought resistance. How can drought resistance be important under such high rainfall conditions? How will niger perform under water logged conditions?

Sharma - The rainfall comes at only certain times of the year, there are long periods with no rainfall. To obtain good seed set, flowering must occur during the dry season when bee activity is high. Since the soil is very shallow in niger producing regions, there is little water holding capacity, thus the crop must produce its seed under very drought conditions.

The crop can do well in saline conditions but we don't have information on its performances under water logged situations but it grows well on bonds of paddy.

Belayneh - Yes, in Ethiopia, niger does better than other crops under water logged conditions.

Omran - Have you used your male sterile material in crosses to produce hybrids? Is the male sterility genic or CMS?

Trivedi -Yes, we have made hybrids using open pollination and controlled hand crossings. The open pollinated hybrids gave about 10% heterosis while some controlled crosses yielded upto 25% heterosis for yield. The male sterility is genic in nature but the male fertile plants can be identified before flowering because of their larger sized buds.

Khalique - Did you say that in your state niger is sown in the Kharif season? In Bangladesh we can not grow niger at that time due to high amount of seasonal rainfall.

Trivedi - Yes, we grow niger as a Kharif crop but sow it late in the season when the rainfall is less.

Badr - What is the oil content of niger? Are you doing any work on oil quality?

Joshi - The oil content is about 30%. There is no need to work on oil quality since the fatty acid composition is very satisfactory and the oil has excellent acceptance in the market.

Zulberti - You listed, as your research priority, the determination of the optimum time for sowing. In many crops, time of sowing has been found to be of less importance than many other factors.

Joshi - Preliminary studies showed that sowing date could greatly affect yield, Thus, we initiated work on this aspect.

4. General

Hadjichristodoulou - Are there data which compare the performance of the minor oil crops with the major oil crops under the same environment in various locations in India? Should research resources be expended to low yielding crops like niger?

Ranga Rao - These crops can not be validly compared because they are adapted to different seasons.

Mangala Rai - There is information to show that other oil crops can not be grown in regions where niger production is now practiced.

Belayneh - In Ethiopia, we did grow all the crops at various locations and sowing times and from that experience we were able to identify the best species for a region and cropping season. Niger was found to have an important place under certain soil and weather conditions.

Badr - Dr. Saharan, You mentioned *Aspergillus* sp. as being an important disease-causing in niger. What species are important?

Saharan - The *Aspergillus* species that attack niger is/are not known although it is sometimes referred to as *A. niger*.

B. Establishment of the Sub-Network

Within the Oil Crops Network, three sub-networks (Brassica, Sesame, and Sunflower) have already been formed. The need arised to deal with the remaining oilcrops. The group had in depth discussions and decided to form a fourth "Other Oilcrops" Sub-network including safflower, linseed and nigerseed. Five members from five countries (2 Africans and 3 Asians) were elected by the group as a sub-network committee. Among themselves, the committee elected their chairman and co-chairman who will be members in the Oilcrops Network Steering Committee.

The elected members were:

1. Dr. V. Ranga Rao (India) - Chairman.
2. Dr. Badr El-Ahmar (Egypt) - Co-Chairman.
3. Dr. M.A. Rana (Pakistan) - Member
4. Mr. Getinet Alemaw (Ethiopia) - Member
5. Mr. Wung Zhao-mu (China) - Member

C. Priorities of Research

Based on the discussions, the group was asked to prioritize the problems and constraints facing the improvement of safflower, linseed and nigerseed, Table 1.

Table 1. Priorities of Research.

Constraints	Countries										
	Egypt	Ethiopia	Pakistan	Nepal	Bhutan	India	B'dsh	China	Canada	Cyprus	Kenya
Safflower:											
Rumularia leaf spot	-	3	3	-	-	-	-	-	-	-	-
Rust	1	3	1	-	-	1	-	3	1	1	-
Alternaria leaf blight	2	3	3	-	-	3	-	2	2	1	3
Salinity	-	-	-	-	-	3	-	3	-	-	-
Wilts and root rots	3	1	1	-	-	3	-	3	1	-	-
Drought	2	2	3	2	2	3	2	3	2	2	2
Aphids	1	-	2	1	-	3	2	3	1	1	-
Spineless varieties	-	3	3	-	-	3	-	2	-	-	3
Earliness	3	2	3	2	-	3	1	1	3	-	-
Dormancy	-	-	-	-	-	-	-	-	2	-	-
Linseed:											
Bugfly	-	0	-	-	-	3	-	-	-	-	-
Pasmo	-	3	1	-	-	0	-	1	-	-	3
Alternaria leaf spot	1	1	1	1	-	3	-	3	-	-	-
Wilt	1	1	1	2	-	3	2	3	-	1	1
Powdery mildew	-	2	2	-	-	2	-	2	-	-	-
Budfly	-	0	-	-	-	3	-	-	-	-	-
Height	-	3	2	-	-	3	-	2	-	1	-
Earliness	-	3	2	2	-	2	3	2	-	2	2
Double purpose var.	-	3	3	-	-	3	3	3	-	-	-
Downy mildew	1	3	3	-	-	2	-	3	-	-	2
Boll worm	-	2	2	-	-	1	-	-	-	-	1
Frost	-	2	-	-	-	0	-	-	-	0	-
Salinity	2	0	1	-	-	3	2	2	-	2	-
Nigerseed:											
Cuscuta	-	3	-	-	-	3	-	-	-	-	-
Drought	-	2	-	3	2	3	2	-	-	-	-
Earliness	-	3	-	3	3	3	3	-	-	-	-
Thermo & photo sensitiveness	-	3	-	3	-	3	3	-	-	-	-
Ideotype suited to different systems	-	3	-	-	-	3	-	-	-	-	-
Cropping systems	-	3	-	1	-	3	-	-	-	-	-
Plant type	-	-	-	-	-	3	-	-	-	-	-
Oil	-	3	-	3	3	3	3	-	-	-	-
Orobanche	-	-	-	-	-	1	-	-	-	-	-
Disease blight	-	2	-	-	-	-	-	-	-	-	-
Boll worm	-	2	-	-	-	-	-	-	-	-	-
Self compatibility	-	2	-	-	-	3	-	-	-	-	-
Leaf spot	-	3	-	-	-	3	1	-	-	-	-

D. Recommendations

The group discussed a set of recommendations to deal with some of the constraints/problems limiting the breakthroughs on the productivity front of safflower, linseed and nigerseed.

1. Cooperative regional nursery:

- This is to be organized under the umbrella of the oilcrops network.

- The number of entries to be supplied by each country appears in Table 2.

Table 2. Number of varieties/lines from each country for the regional variety test.

Country	Safflower	Linseed	Niger
Ethiopia	1	2	3
India	4	4	4
Canada	1	3	-
Pakistan	1	3	-
Egypt	2	2	-
Bangladesh	1	-	1
China	2	1	-
Cyprus	3	-	-
Kenya	-	1	-
Nepal	-	1	1
Bhutan	-	-	1
Total	15	17	10

- The coordinators for the three regional trials are:

Safflower: Dr. M.A. Rana.
Linseed: Dr. Badr El-Ahmar.
Nigerseed: Mr. Getinet Alemaw.

- The coordinators will draw up guidelines for the trial, (the layout and common format for reporting basic information including cropping system to be followed- deadlines for despatch of data base to coordinators-locations-...etc.)

- The participating centers would send 1 kg (linseed-niger) or 2 kg (safflower) to the Network adviser by March-June 1989, adopting all phytosanitary regulations for re-despatch to all trial centers.

2. Disease nurseries:

- The Network/sub-network may organize, as and when facilities are created, international disease nurseries for each of the major biotic constraints/stresses in their respective hot spot areas to facilitate identification of potential donors for exploitation in resistance breeding programs. The priority areas in order of importance are:

Safflower : Alternaria, wilt, root rot.
Linseed : Wilt, powdery mildew, Alternaria.

3. Information:

- Because of the scanty information available, the participants called for a critical and comprehensive review (current status, screening criteria/procedures, potential donors,...etc.) of the already available information base in the world. The following resource persons were identified to prepare these reviews:

Safflower - earliness: Dr. V. Ranga Rao.
Safflower - Diseases: Dr. G.S. Saharan
Niger - Self compatibility: Dr. Hiruy Belayneh.
Salinity in 3 crops: Dr. Mangala Rai.

4. Training:

- The committee is to seek support from IDRC or other agencies to organize a training program on screening techniques and culture scoring methods for Alternaria leaf blight and other diseases.

- The training could be for 2-4 weeks.
- The possible venue could be the Directorate of Oilseeds Research, Hyderabad, India. Countries showing interest are: Egypt, Kenya, Pakistan, India, Nepal and China.

5. Germplasm exchange:

- The coordinators will ask for germplasm exchange of spineless safflower, edible linseed, self-compatible niger,....etc. Global germplasm should be accessible.
- Specific centers should be strengthened for conservation, maintenance and utilization of alien species in the improvement of cultivated species through modern biotechnological tools and supply of early generation derivatives of interspecific crosses to the participating countries.
- The committee should seek support to set up a center for active and base collections of germplasm preferably in potential areas of their culture.

Part III.

Steering Committee-I

(Oilcrops Network)

Hyderabad, India

16-17 January, 1989

THE OILCROPS NETWORK FOR EAST AFRICA AND SOUTH ASIA, ACHIEVEMENTS AND FUTURE

Abbas Omran

Pre-Network (1970's)

The importance of vegetable oils and fats in the diet of the peoples of the developing world is very great, and many millions of third world citizens have a totally inadequate intake of oils and fats. The commercial importance of the oilseed crops is well known, and prices are likely to remain high for many years to come. This very factor operates to the disadvantage of the nutrition of the rural poor, who in their dire need for cash are forced to sell the oilseeds they have grown, thus depriving themselves and their families of a basic nutritional requirement.

National programs in East Africa and South Asia were, and are, conducting research on oilseeds for a long time. Many of these programs were strong but there were always difficulties in basic research, training, germplasm availability, information ... etc. Many of these scientists were working in their remote stations isolated from all world development.

This situation was recognized by the International Development Research Center (IDRC) who devoted considerable efforts to support national programs working on annual edible oilseed crops in Egypt, Sudan, Ethiopia, Tanzania, Malawi and Mozambique in Eastern/Southern Africa; India, Sri Lanka and China in South Asia, Fig. 1.

Establishment of the Network (1981)

The most appropriate strategy to meet the needs of crop improvement for oilseeds was to implement a network. This approach has already proved its value through the IDRC networks on cassava and cropping systems, and is contributing to agricultural improvement in other crops, such as cowpeas. It was proposed that the first network for the oilseed crops should be established in the Indian - Eastern African regions.

The initial step in the creation of the network was the identification of a scatter of individual projects. With several of these already established by IDRC, the network could be formed, Fig. 2.

The critical feature of a network is the linking together of the individual projects so that there is a steady flow of information, plant materials, ideas and experiences between all the projects. The best way of achieving this was through a network adviser, as has been clearly demonstrated in the South East Asian Cropping Systems Network. The function of a network adviser was therefore: to fulfil the basic functions of an International Center in so far as the provision of information, the gathering and distribution of germplasm, practical guidance, and the conduct of workshops for involved scientists concerned.

The appropriate location for the Netowrk was Ethiopia which is a primary source of diversity for most oilseed crops and has a wide range of oilseeds covering ecological zones stretching from sea level to 3,000 meters a.s.l.

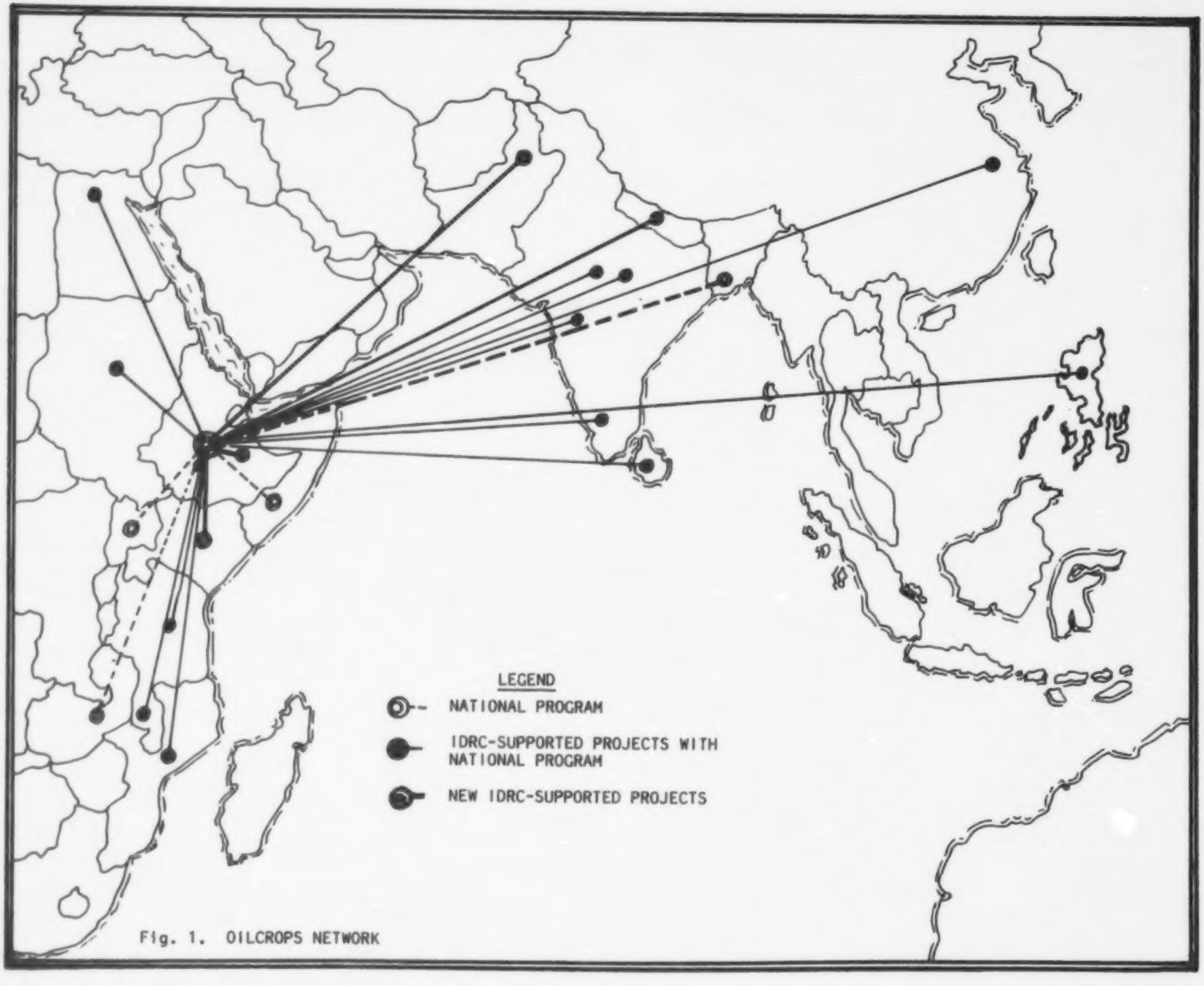
LEGEND
NATIONAL PROGRAM
IDRC-SUPPORTED PROJECTS WITH NATIONAL PROGRAM
NEW IDRC-SUPPORTED PROJECTS

Fig. 1. OILCROPS NETWORK

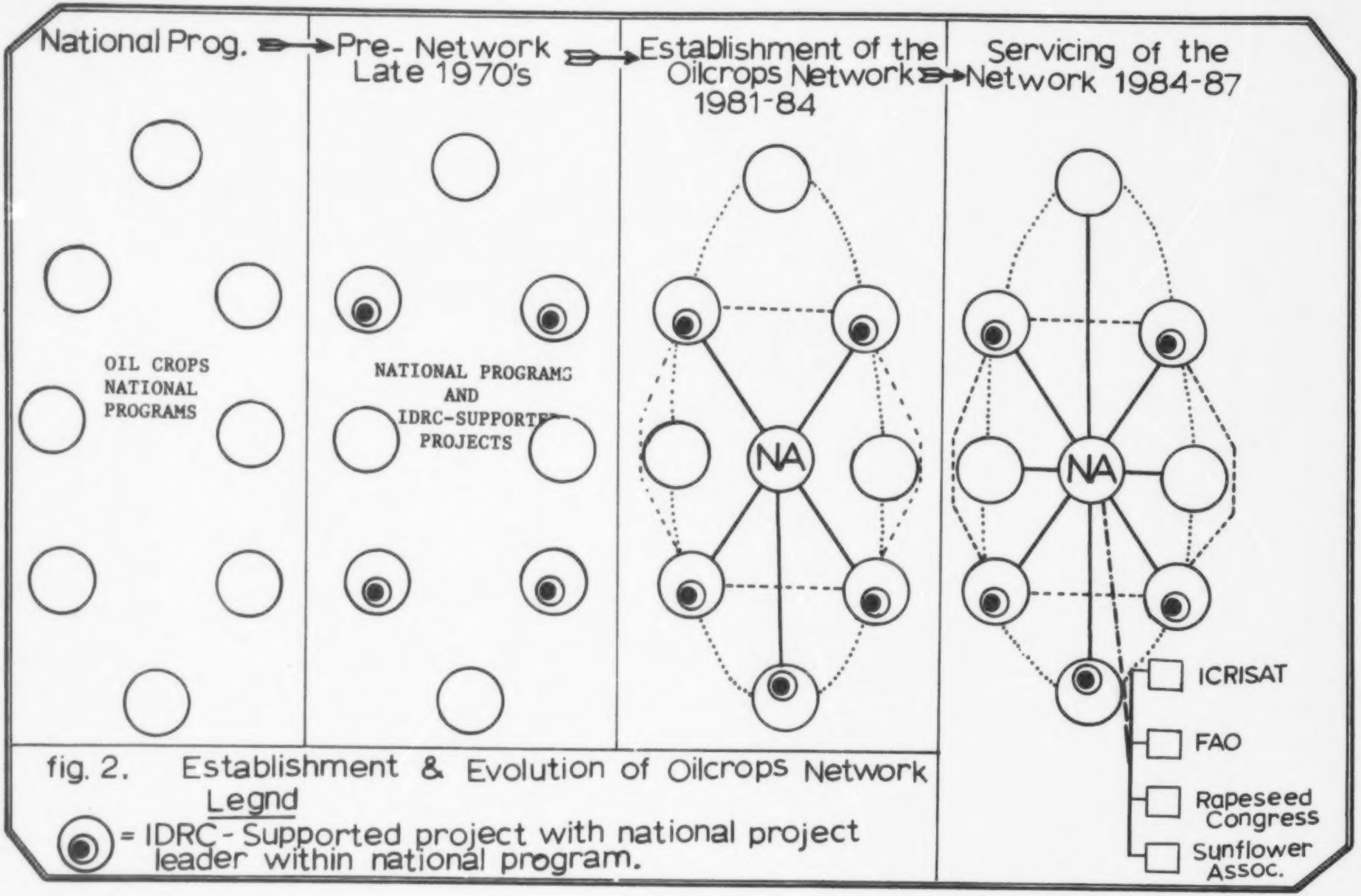
National Prog.
Pre- Network Late 1970's
Establishment of the Oilcrops Network 1981-84
Servicing of the Network 1984-87
OIL CROPS NATIONAL PROGRAMS
NATIONAL PROGRAMS AND IDRC-SUPPORTED PROJECTS
NA
NA
ICRISAT
FAO
Rapeseed Congress
Sunflower Assoc.
Legnd
= IDRC- Supported project with national project leader within national program.

fig. 2. Establishment & Evolution of Oilcrops Network

Network Phase I (1981-84)

The general objective of Phase I was to establish effective,practical liaison between the IDRC oilseeds projects in Eastern/ Southern Africa and the Indian Region; meanwhile assisting in the establishment of the Ethiopian Oilseed Projects.

The objectives were achieved by:

- Establishing the Network in Ethiopia.
- Identifying the Network Adviser.
- Establishing two oilseed projects in Ethiopia.
- Developing an oilcrops library and computer references.
- Linking IDRC-supported oilseed projects through correspondence and visits.
- Holding the first Oilcrops Network Workshop in Egypt, September 1983 with 25 participants (mostly project leaders) from 11 countries presenting 25 papers. The proceedings were published as an IDRC Manuscript Report MR93e, 178 pp.
- Attending the First Regional Groundnut Workshop (ICRISAT/ IDRC) in Malawi.

Network Phase II (1984-87)

The general objectives remained as for Phase I. The emphasis shifted from establishing the network to servicing and operating the network. Specifically, the Network adviser aimed to continue working with the Ethiopian highland and lowland oilcrops projects, to visit each project of the Network, to keep IDRC program officers in good touch with the situation, to publish an annual newsletter, to arrange for interchange of visits between scientists, to help in germplasm exchange, and to organize workshops.

The objectives were achieved by:

- Continuously helping the research activities of the Ethiopian lowland and highland oilcrops and offering courses in statistics/experimental design to researh officers/technicians of the Institute ofAgricultural Research and to graduate students of Alemaya University of Agriculture.
- Distributing cover pages of the most important international journals to researchers and sending back photocopies of requested papers, computer printouts of references and abstracts.
- Arranging consultation for Ethiopia, Sudan, Egypt and Nepal to advise and assess the project developments.
- Linking together scientists from different projects who share the same crops and same problems; a visit of Dr. Thangavelu (Sesame, India) with Mr. Yebio Woldemariam (Lowland Oil Crops, Ethiopia) and Dr. H. Ishag (Oilseeds, Sudan) proved very fruitful in strengthening the links. Dr. Sawant (Safflower, India) visited Safflower work in USA, Mexico and Spain.
- Contributing to a cooperative program with Agriculture Canada (Anther Culture Project) by sending the network assistant and an Indian professor to work on the project for 2 years.
- Visiting non-IDRC supported national projects and helping to secure small research grants to ease the bottlenecks in on-going research (Tanzania), and to

start germplasm collections (Somalia).

- Organizing a training course in India on sesame/safflower for 15 junior research assistants/ technicians from Africa and Asia. The adviser participated in teaching and coordinated the course with the Directorate of Oilseeds Research, Hyderabad.

- Conducting two workshops:

  1. Workshop II held in India, February 1985 emphasizing sesame and safflower, with 38 participants from 12 countries presenting 22 papers (IDRC MR105e, 258 pp).

  2. Workshop III held in Ethiopia, October 1986 emphasizing Brassica and niger, with 39 participants from 11 countries presenting 29 papers (IDRC MR153e, 250 pp)

- Attending the 11th International Sunflower Conference in Argentina and the Second Regional Groundnut Workshop (ICRISAT/IDRC) in Zimbabwe, to establish relations with international organizations. Editing and publishing three issues of the Oilcrops Newsletter: No. 1 (1984), No. 2 (1985) and No. 3 (1986). More than 600 copies from each issue were dispatched to oilseeds workers around the globe.

- Establishing the first Sub-Network (Brassica) and holding the first Brassica meeting in Sweden, May 1987 with 12 participants from 8 countries, presenting 9 papers (IDRC MR168e 80pp). This was followed by accompanying the participants to attend the 7th International Rapeseed Congress in Poland and establishing relations with Rapeseed Congress.

Network Phase III, (1987-89)

The overall objective of this interphase is to strengthen the oilseed research carried out in Eastern Africa and South Asia by establishing effective, practical liaison between the national oilseed programs. The specific objectives are: to continue support that will increase the effectiveness of national oil crops programs in the region; to establish the most effective mechanisms for the exchange of oil crops germplasm in the network; to continue the flow of needed information to national oilseed programs; to provide middle level technical training on oilseeds; and to evaluate the feasibility of new network forms (sub-networks and new International Unit) in increasing network effectiveness and efficiency. This phase III is termed "interphase" between the network as it was and the new development of our International Oilcrops Research Unit (IORU).

These objectives are being achieved so far by:

- Holding workshop IV in Kenya, January 1988 with 67 participants from 21 countries, presenting 50 papers (IDRC MR205e, 350 pp.) FAO, IBPGR, SIDA, CIDA, USAID, ODA, EEC and many Kenyan private Enterprises contributed to the participation in the workshop. The future of the network was discussed and laid out.

- Continuing national programs support by working with projects (Ethiopian lowland oilcrops and sunflower programs), and supporting national workshops (Kenya, 1987). More emphasis is being given to interacting with national programs which do not have IDRC support. Where necessary, National Program Support funding is allocated from the Network project.

- The dialogue between Indian and Ethiopian germplasm officials is being followed up to ensure that bilateral exchange continues between these two countries. Other network countries with fewer constraints to exchanging germplasm, are encouraged to exchange on a bilateral basis.

- The collaborative nursery, as recommended at the 3rd workshop is instituted using Ethiopia as a base for receiving the seed samples and distribution of the nursery. The process of the nursery receipt and dispatch will be continuous. In some cases, seed will need to be multiplied in Ethiopia before dispatch. All network members are again urged to participate. Samples received and distributed up to June 1988 are listed in Oilcrops Newsletter (No. 5:10-12, 1988). Each country received all samples of the same crop(s) they contributed. Samples received up to December 1988 are shown in Table 1.

- All projects, even the discontinued ones, receive computer printouts of references pertaining to their crops. It is made sure that national programs receive oilseeds abstracts, computer profiles and searches when needed. A bibliography on sesame diseases is in print for publication.

- As recommended by the participants of the previous workshops, training in all disciplines is being considered. P.R. China, Pakistan and Ethiopia have offered to conduct training on breeding, agronomy and quality aspects. This will be discussed and finalized during these January 1989 meetings.

- FAO agreed to coordinate publications of sesame and safflower between the "Oilcrops Newsletter" and their "Sesame and Safflower Newsletter". A group of scientists including the Network Adviser met in Vienna for FAO and formulated an international sesame project. The main objective is to support sesame producing countries in their efforts to improve the agricultural production and the socio-economic status of their populations through sesame improvement. The project aims also to strengthen national institutes, build strong genetic basis for sesame, build an efficient network for information and material exchange. The project was endorsed by participants of the Fourth Oilcrops Network Workshop held in Kenya in 1988.

- Four sub-networks under the umbrella of the mother Oilcrops Network were formed, Figure 3:
  1. Brassica sub-network, formed May 1987
  2. Sesame Sub-network, formed January 1988
  3. Sunflower Sub-Network, formed January 1988
  4. Other Oilcrops (linseed, niger, safflower, ...) is formed during January 1989.

- The four sub-committees can decide their activities and meetings. It is suggested that each can meet once every 18 months and that the chairman and co-chairman participate in the common workshops with selected members from each sub-committee as relevant to workshop themselves.

- Members of the sunflower sub-network were supported to attend the 12th International Sunflower Conference (Yugoslavia, July 25-29, 1988) and established relations with the Sunflower

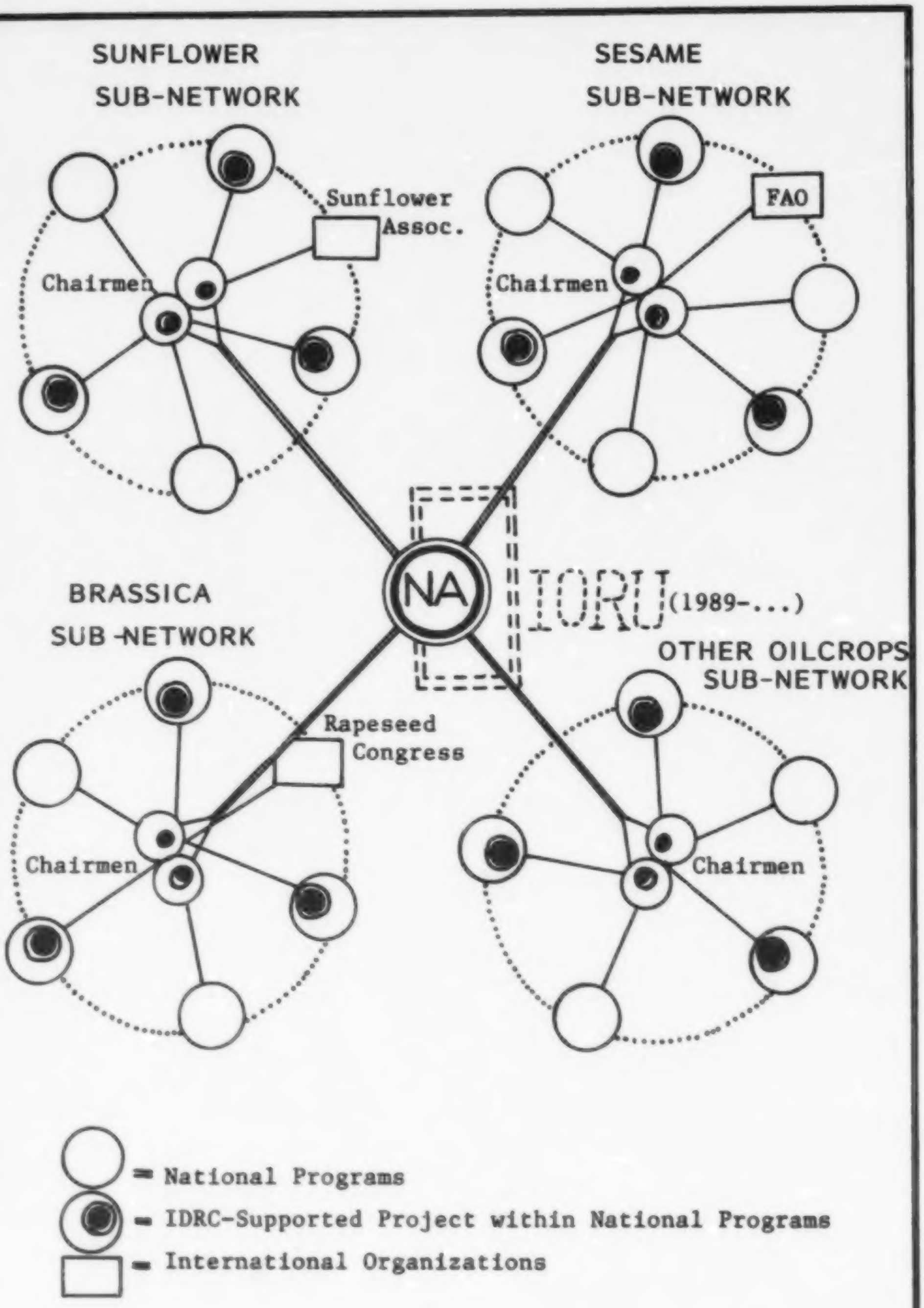
SUNFLOWER SUB-NETWORK
SESAME SUB-NETWORK
Sunflower Assoc.
FAO
Chairmen
Chairmen
NA
IORU (1989-...)
BRASSICA SUB-NETWORK
OTHER OILCROPS SUB-NETWORK
Rapeseed Congress
Chairmen
Chairmen
= National Programs
= IDRC-Supported Project within National Programs
= International Organizations

Fig. 3. Developing The Oil Crops Network (1987-89).

Associations and the FAO/Yugoslavia Sunflower germplasm and breeding branch.

- The steering committee of the Network includes 10 members (2 from each sub-network plus the Network adviser as secretary and the IDRC Program Officer responsible for the Network). Meetings are scheduled so as the Network steering committee can meet annually with any of the sub-network meetings.

Table 1. Oilcrops Network Nursery: samples received and dispatched up to December 1988.

	OILSEED CROPS						
Country	Brassica	Linseed	Nigerseed	Safflower	Sesame	Sunflower	Groundnut
Nepal	11	1	1	-	1	-	4
Sweden	8	-	-	-	-	-	-
Ethiopia	5	2	8	-	9	8	-
China	8	-	-	-	-	-	-
India	31	-	-	-	-	-	-
Egypt	-	-	-	10	10	-	-
Somalia	-	-	-	-	13	-	-
Philippines	-	-	-	-	16	-	-
Sri Lanka	-	-	-	-	3	-	-
Israel	-	-	-	-	21	-	-
Kenya	-	-	-	-	2	-	-
FAO	-	-	-	-	49	-	-
Tanzania	-	-	-	-	9	-	-
Canada	-	-	-	-	-	45	-
Cyprus	-	-	-	6	-	-	-
Nicaragua (FAO)	-	-	-	-	9	-	-
Total	63	3	9	16	142	53	4

The proposed oilseeds unit

Some oilcrops are receiving considerable attention from International Organizations like groundnut (ICRISAT) and soybean (INTSOY and IITA), and some are receiving moderate attention like rapeseed/mustard (GCIRC) and sunflower (International Sunflower Association). Yet some crops are receiving little or no attention like sesame, linseed, nigerseed, safflower and castor.

IDRC contacted several donors who showed interest, then IDRC thought to start a nucleus of an International Oilcrops Research Unit. Support for oilcrops will expand as additional resources become available over time. The objective is to develop a small, flexible, multi-donor-supported research unit to provide scientific and technical back-stopping and coordination to researchers primarily in Eastern and Southern Africa and South Asia working on annual oilcrops.

The Ethiopian Government has agreed, in principle, to have the Unit established in Ethiopia.

The Network will be attached to the proposed Oilseed Unit as a satisfactory base to help the Unit in their regional activities. The adviser can participate in research as a member of the Unit. In addition to the Coordinator, the Unit will comprise, initially, 2-3 scientists. Other positions, supported by additional donors, will be added later. The Unit would also employ short-and medium-term consultants.

Some of the initial efforts are:

a) To screen germplasm and to generate more variability for national projects,
b) To incorporate important resistances into good national material,
c) To distribute nurseries for testing, including to NGO's where appropriate,
d) To develop male-steriles and breeding populations; and assess the practicability of hybrids in due course,
e) To develop and use tissue-culture technology as needed to facilitate the above,
f) To study the possibility of resistance breeding against Orobanche and Cuscuta, and
g) Training will be one of the main activities once the Unit is well established.

RECENT DEVELOPMENTS IN THE OIL CROPS NETWORK AND THE ORU

Hugh Doggett

Philosophy

The value of an association of research projects became apparent to me when I was working on sorghum in East Africa. I began as sorghum breeder to the then Tanganyika Government, a plant breeder in a national program and responsible to it. That has always influenced my thinking: the basic unit is the national program. Various forms of collaborative research may be undertaken, but their purpose is always to strengthen the individual national program of each of the participating countries.

The East African Community then accepted responsibility for sorghum research, and the main breeding work was moved to Serere in Uganda. The sorghum breeding was being done for the three individual States of Kenya, Tanganyika, and Uganda. In no sense were their sovereign national programs directed from Serere: rather, there was excellent co-operation, especially over testing and the reporting of performance. Eventually, the governments of the three territories released Serena and Seredo at different times. I believe that today these same two cvs show promise in the lowlands of Ethiopia.

The second formative influence occurred during my early days at ICRISAT. I was in a field of most interesting diverse sorghum breeding material, when a very senior ICRISAT administrator walked into the field, came up to me, and said "Show me something that is better than CSH-6". That has always remained in my mind: I did not see it as my task to produce something that was better than CSH-6. Dr. NGP Rao had an excellent national sorghum breeding program. My function was to support that program by working with the whole spectrum of the sorghum germplasm to sort out and develop material which Dr. Rao and his able team could exploit to produce something superior to CSH-6.

The third formative influence was furnished by the Asian Cropping Systems Network. Some of my IDRC former colleagues were involved in its development, and it has always provided an excellent model in my thinking. Technology was being generated at IRRI and in the IRRI area. This was being taken by the national agricultural research programs of S.E. Asia, tested, modified, and adapted to their own specific conditions, through co-operation with their farmers in cropping systems research projects. It was these national programs that took the new varieties, together with the suitably modified technology, to their farmers. To me, a key figure in all this was the Network co-ordinator, Dr. Pexy Carangel. He was not a Director, nor a Director-General, Directors tend to look for someone to direct. Pexy was a facilitator, a "guide, philosopher, and friend", if I may be allowed to repeat my favourite phrase. Pexy saw his task as one of helping the staff in the national projects with advice and information, especially about what other similar groups in the Network were doing. He arranged workshops: he arranged visits between the projects for the researchers to see on the ground what others were doing, and to talk together about their problems. My definition of a "Network" is an association of co-operating national projects linked loosely together, assisted by such an Advisor, or co-ordinator, call him what you will, as a guide, philosopher and friend. I do not care to use the term "Network" unless this kind of Advisor is a key component of the association. Hence, I stress my definition. (ICRISAT, in cooperation with IDRC, will soon be producing a publication on networks, written by Dr. Don Fris, of the Pigeon Pea program: I have not seen it, and his definition may well differ from mine).

The Oil-Crops Network

Size

The original broad plan for the Oil crops Network was based on the fact that the Ethiopian annual crops, including the Oilcrops, had spread to the continent of India, and also down through eastern Africa in ancient times. The crop populations had then been separated for two to three thousand years, building up genetic differences in response to various selection pressures both human and ecological Intercrossing these populations should yield very fruitful results. There is much germplasm in Africa, and there is much scientific and technical skill in the Indian sub-continent: it was felt that a network of projects located both in Africa and in India would help to bring these two advantages together, and a mutually profitable network might be developed. The Network Adviser (Coordinator) was based in Ethiopia. I negotiated the first three Indian projects in 1975-76, while at ICRISAT, but they did not come through until 1978. The Highland Oilseeds and Lowland Oilseeds projects were then begun in Ethiopia, and Dr. Ken Riley became the first Network advisor, while also having an input to the national projects. Other projects were developed in Egypt, in the Sudan, and in Sri Lanka. Links with an ODA-supported project in Tanzania were also made.

In February 1986, a small sub-committee suggested that surveys should be done to look at the potential for oil crops projects in Kenya, Tanzania, Uganda, Malawi, Nigeria, Cameroun, Nepal, Bangladesh, and Pakistan.

My first question is: "How big should the Network be? We do not yet have support from other donors: how are the limited funds available best used? " I shall return to this at the end of this paper.

Research Inputs

There are no International Centres dealing with the oilcrops in our Network: we have deliberately excluded those crops which already receive a good measure of scientific research support. These include groundnuts, soya, and cotton. Dr. Hawtin was concerned about this aspect, and after correspondence and discussion, it was decided to sub-divide the oilcrops projects, and to group them into sub-networks by crop. Two of these sub-networks (Brassica and Sunflower) already have available a useful volume of scientific research work from the Developed World, both have Newsletters and good links among themselves. We foresaw no serious difficulty in getting the appropriate IDRC sub-networks linked in to these; the Brassica link-up has already been made, and the meeting held last week was the first since the inaugural meeting. A Sesame sub-network was established at the 4th Oilcrops Network workshop held in Kenya. That leaves safflower, niger, linseed, and perhaps castor as "other oil crops" Dr. Abbas Omran hopes to have the Other Oilcrops sub-network established very soon. Having just attended the second International Safflower Conference, I can see a strong case for making that into a sub-network also. Much research is in progress, and there is already the FAO Sesame and Safflower Newsletter. I believe that when productive spineless types are available. There will be pressure to extend safflower down into Africa.

Dr. Hawtin suggested that the Oilcrops listed as "Other" above need stronger scientific research support, they are largely neglected at present. This list would certainly include sesame. He suggested the establishment of a research unit; This might be called the Oil crops Research Unit" (ORU) and in the first instance, this should work on sesame and niger, linseed could be added at a later date, and even castor might be added later. We would hope to encourage other Donors to join in supporting such a scheme, and it should certainly operate in an international manner, even though not linked in any way with CGIAR. However, we would be unwise to include the word "International" in the title. That will give rise to the wrong kind of image - that of a large Institution with ample funding. The ORU is unlikely to be such a unit, at least for a period of years. Initially, it will have a small staff, and rather little money for the task ahead of it.

Here I would add two more questions:-

2) How are the sub-networks to be operated? and 3) Have the crops requiring additional research support from ORU been correctly identified?

The Proposed Oilseed Crops Research Unit (ORU)

The Objectives

These are based on the originally stated by Dr. Hawtin in his letter of 19.06.87 to Dr. Seme Debela: To develop a small, flexible, multi-donor- supported research unit to provide scientific and technical back-stopping and coordination to researchers in Eastern and Southern Africa and South Asia working in the annual oilcrops Network. ("South Asia" includes India, Pakistan and Sri Lanka).

Initially, the Unit would concentrate its activities on sesame and niger. Support for these, and for linseed, will expand as additional resources become available.
The coordination and training activities of the existing Oilcrops Network will be absorbed by the Unit and the Oilcrops Coordinator will become a member of the staff of the Unit, but retaining essentially his present functions.

Ethiopia, as the host country, is expected to be a major beneficiary of the Unit, which will be run in close collaboration with IAR.

The Crops

Oilseed Crops of the Afro-Indian region lacking strong research support include sesame, niger, linseed, and possibly castor.

Sesame is grown in many countries of the world, and rather recently FAO has become aware of its importance. There were excellent presentation at the last oilcrops workshop. Prof. Amram Ashri has been doing very good work, and a project has been put forward to UNDP for funding. This has been planned on a global scale, with a price tag of 1.6 million US dollars, although it has not yet been funded. Such a development is wholly to be welcomed, and we all hope that the money will be made available by UNDP. This need not influence our ORU plans: we should go steadily ahead, concentrating on our clearly defined areas of concern. As soon as the FAO project is operational, we can look forward to close cooperation and exchange of germplasm and technical information. The general consensus in the correspondence reaching me is that sesame is widely grown and important in many countries of the Afro-Indian network region. At the last Oilcrops Workshop, Prof. Ashri quoted the area of sesame as 6,670,000 ha, all but 4,000 of which are grown in the Developing World. The 1985 data from FAO show that 22 countries are major sesame producers. It is important that back-up research work on this crop in the Afro-Asian region should be started as soon as possible. Let us not be confused by the past usage of this word "International" in relation to ORU: we are not competing for world leadership in sesame research: we simply want to get multi-donor supported back-up research started for the benefit, initially, of those countries in the Oilcrops Network. We desire close cooperation with FAO, and trust that they will be able to provide world leadership in this field in due course.

Niger is another important crop in the region with which we are involved, it is produced in Ethiopia, India, Bhutan and Nepal. It was formerly much more widely grown in Eastern Africa. This crop is of great interest: sunflower has proved to be very flexible in the way it has become an important oilseed crop of recent years in the USA, Europe, and now in the tropics. Some of us have been considering safflower, another new oilcrop developed from a plant traditionally grown for its dye. Niger is a relative of sunflower and safflower, with better tropical adaptation. I expect work on niger improvement to be very rewarding. I think that we shall be surprised by what that crop achieves. Work on sesame and on niger will mesh in well together: the one is a lowland crop, the other a hill crop. The research will be complementary, not competitive, and in this way a wider range of farmers will be served.

Sesame and niger I judge to be the two oilcrops on which to start work. As and when opportunity offers, linseed could be added to the niger zone research, especially using the types suitable for human food (Low linolenic). Safflower could be added to the sesame zone research, if thought desirable.

The Location.

In view of the need for:

i. good international communications (telephones, telex, and easy access to the international airport);
ii. living conditions (access to schools, hospitals, provisions, and social life) which will attract well-qualified mid-career scientists (and also other donors);
iii. an environment in which the annual oilseed crops can be grown - or within easy access of such environments; and
iv. a location able to cater for the needs of students and trainees; it is suggested that the Unit should be based at Debre Zeit, Ethiopia. Since this is 50km from Addis Ababa a small administrative front office in the city will also be necessary.

The choice of sites will be governed by what is agreeable to national government policies. In Ethiopia, Melka Werer would be very suitable for sesame, especially as a series of rainfed trial sites has been developed in differing rainfalls and at various altitudes, associated with the Melka Werer project. A sesame nursery should be satisfactory at Debre Zeit, with a larger area of breeding material at Melkassa or Mieso. Debre Zeit would do well for the niger breeding nursery, with a larger area at Ghinchi.

In addition to these main research locations, it is hoped that other IAR testing sites will also be available to the Unit (especially in rainfed areas), and that all the field testing activities will be regarded as an integrated program between IAR and the ORU.

Other sites suitable for sesame include Pawe, Beles, Babile, Bisidimo, Abobo, Didessa, and Asosa, Other sites suitable for niger include Holleta, Denbi, Adet, Mota, Bichana, Dabat, Gohatseon, Shamsu and Asosa.

We are fortunate in working so close to the Equator: it will be possible to have another season south of the equator, which would greatly speed the work, as the number of generations that can be grown is very important. We should seek help from the Govt. of Tanzania to use land at Naliyendele (near Mtwara) for sesame work, and land at Uyole station, near Mbeya, for niger work. These sites are approximately mirror-image relative to those suggested in Ethiopia, across the equator.

The Staff

The staff will consist initially of two full-time breeders, one for each crop, an agronomist, and three post-doctoral fellows. Other positions will be added later, supported by various donors. The two breeders, together with the agronomist and the co-ordinator, will form the core of the Unit. Other disciplines will be added by linking local postgraduate students or pdf's with Institutions supported by other donors. The donors would provide visiting consultants who would guide the planning and implementation of the research in these other fields. For example, Dr. Bill Reed, might be supported as a consultant on entomology by ODA. There might be two or more trainee entomology researchers in the field. Dr. Reed would develop the entomology program during a visit to the Unit, and would continue to monitor the activities of the local entomologists through consultancy visits at intervals. There would be provision for research students to obtain appropriate research degrees. Similarly, a Canadian scientist might be a consultant on the plant pathology aspects: he would also advise local pathologists-in-training, and keep close contact with the plant breeders. It might be possible to handle the post-harvest and quality work in a similar manner, although it may later prove necessary to augment the core staff numbers in one or more of these areas.

Housing

By handling the research in this way, the number of international scientists requiring housing will be minimized. The Unit will need to build some houses, not only for the resident scientists, but also perhaps a suitable rest-house for the visiting consultants, who may be expected to need several weeks for some of their visits.

A research organization of this type would place great emphasis on the work of the local scientists. This is where the greatest benefit will accrue to the national program. I was impressed on a recent visit to Tanzania by the number of enthusiastic young scientists returning from overseas, well trained and full of enthusiasm for a research job. I am sure that the same must be true in Ethiopia. In this network program, there will be much really worth-while research to be done, and the combination of resident plant breeders and agronomist with regular consultant discussion and guidance from visiting scientists will build up a valuable base of experienced local scientists in the countries involved.

The Program

The plant breeders will build up germplasm collections of the crops in the program, in close partnership with PGRC/E, and some money will be needed by PGRC/E for the extra work that will be involved. Cooperation in screening the material may be expected to be close. Good multilocational testing will be done, and germplasm movement between Africa and India will be encouraged, with due precautions taken. This may well involve a need for tissue culture. Given this (safe) movement, intercrossing the germplasm from the two continents may be expected to result in substantial genetic advances.

The agronomy results may be of considerable interest: niger has some unusual effects on weeds, and on the following crops. As evidence accumulates, it will be possible to assess with much greater certainty the need for more resident scientists of high calibre. A low-key start, while learning how best to operate a "learning together" system of this type, will lay the ground-work for an excellent cooperative research program later on.

Questions

1. How big should the Network be?

I suggest that we should look carefully at the size of the area to be covered. The amount of travelling that the Adviser can do is limited by both time and cost. At each project he visits, he must have time to spend on proper field visits and discussions. We need to be very careful about adding to the size of the Network until additional donors have joined with us in providing support for it.

The second aspect of this same question is the amount of time that Program Officers (PO) can spend on developing and managing oil crop projects. It may not be possible to increase the number of projects in a given area because the PO and his office staff are overloaded. We should consider carefully the inputs that the Network Advisor can make in the field. Perhaps if he had an assistant, he could relieve the PO of some of the load involved in starting and managing the oilcrops Network projects.

2. How are the sub-networks to be operated? How will the Advisor's input be assured?

At present, there are two chairmen for each Sub-network: but both are busy scientists without spare time to give to the management of the Sub-network. There will be correspondence and administrative work in connection with Network activities, while laying on a Workshop is a really time-consuming business. I suggest that a Chairmen's Assistant should be appointed to each Sub-network, to deal with Netwrok affairs. He/She would be answerable to the Chairmen, but also closely in touch with the Network Adviser (co-ordintor).

The Adviser's monitoring visits could be done in part by scientists working on the crop from another research group elsewhere, on a consultancy basis.

3. Have the crops requiring additional research support been identified correctly?

There is no way in which the answer can be an unequivocal "yes". The Brassica man may feel tat the returns on the same amount of investment in his crop would be far greater than will be the case for sesame or niger. The sunflower man likewise. This arguments is not valid when the research effort put into the oilcrops has been so uneven. The West has got on to the Brassica, the soya, the peanut, the sunflower band-wagons. Negligible effort has gone in to sesame and niger. They could both have a useful place in tropical farming, and we are going to need everything that has a useful place. Let us have a go, but not as fanatics. See what 10 years sustained effort can do: then re-assess the overall picture. I would like to feel that ORU is the beginning of a real research unit servicing the oilcrop needs of the Tropics. Once the neglected crops are in hand - they soon will be - then I would like to see ORU tackling specific problems, without regard to which oilcrop is involved. We must give the neglected crops a fair crack of the whip first, without that, we cannot assess their value: but from then on, ORU should look for winners, then back them.

4. How do we handle germplasm? The collection, classification, movement and intercrossing of germplasm is of supreme importance. How do we set about it?

The IBPGR approach, if I have understood it correctly is that germplasm belongs to mankind, and should be freely available to all. Some individual developing countries have a different view: they feel that people (especially that avaricious mob knows as "The West") will take their germplasm, develop wonderful varieties and hybrids from it, patent them through "Plant Breeders' Rights", and make a fortune selling the products back to them!

We have to accept that these two views exist, and are often strongly held. I would go along with Dr. Seme Debela's view: make bilateral agreements on germplasm and its movement; that gives leverage if it is needed. Permit only released germplasm to be exported, even to countries sharing a bilateral agreement. I think that will work: where there is goodwill between countries, and a common objective such as the improvement of an oil crop, then I am sure that mutually agreeable arrangements will be reached on germplasm release.

IBPGR'S NEW CONCEPT FOR THE CONSERVATION AND UTILIZATION OF GERMPLASM; GLOBAL CROP NETWORKS

J.M.M. Engels

Recently the mandate of the International Board for Plant Genetic Resources (IBPGR) was expanded and has been formulated as follows:

"To further the study, collecting, preservation, documentation, evaluation and utilization of the genetic diversity of useful plants for the benefit of people throughout the world. IBPGR shall act as a catalyst both within and outside the CGIAR system in stimulating the action needed to sustain a viable network of institutions for the conservation of genetic resources of the plants".

In order to meet this mandate, it was necessary to reorganize and restructure the programs of IBPGR drastically and to add a new dimension to its operations, strategic research.

The New Basic Program Structure

Administrative Program, comprising directorium, publications and public affairs.

Field Program, embracing the global genetic resources network, germplasm acquisition, germplasm characterization and evaluation, documentation and training.

Research Program, including *in-vitro* culture and cryopreservation research, genetic diversity studies and seed conservation research.

As part of the field program a network of eight regional offices have been created, each headed by a Regional Coordinator. In the region of the Brassica and Other Oilcrop Sub-Network the following offices are involved: Nairobi for Eastern Africa, Rome for the Mediterranean + Northern Africa + West Asia, New Delhi for South and Southeast Asia and China for East Asia.

The Global Crop Networks

In order to cope better and more efficiently with the changing demands and needs for germplasm conservation, IBPGR recently developed a new concept for the conservation and utilization of plant genetic resources. Instead of designating a genebank to assume global responsibilities for the conservation of germplasm of a given crop it is proposed to form a global network of germplasm curators, plant breeders, research workers and others dealing with a given crop. Such network can be represented through a crop advisory committee and should be given the responsibility to set priorities, to coordinate/initiate activities in the field of:

- Germplasm collection: "gaps" in to be identified existing collections and setting priorities for collection, including wild related species, if relevant;

- Germplasm conservation: make proposals where the global base collection(s) should be kept and where active collections are required i.e. on a regional basis;

- Characterization and evaluation: develop or revise descriptor lists relevant to curators and users; set priorities for characterization and evaluation work; define "hot spots" for disease resistance screening, etc.;

- Documentation: make proposals for global crop data bases, comprising information on the existing collections, evaluation of data, etc.;

- Research: formulate priorities of research work needed in order to conserve and utilize germplasm more effectively;

- Training: identify areas where more training is required and make proposals how to fill such gaps.

IBPGR will support and assist in the establishment of such crop networks wherever possible. At present, eight crops have carefully been selected to start "pilot network" in order to gain experience and to channel the limited resources in a more concerted manner. These crops chosen for the initial stage are: maize, barley, sugar beet, groundnut, banana, sweet potato, medics (forages) and okra. Although the field activities of the coming year will be mainly geared towards these crops no possible opportunity should be left out to start networks for other crops.

The Brassica and other Oilcrop Sub-Networks, sponsored by IDRC are excellent "crystallization points" which can serve as the initial stage for global networks. It is therefore, proposed that the present Brassica and Other-Oilcrop Sub-Networks Meetings consider the possibilities to take the initiative and to make proposals for the establishment of the respective global germplasm networks.

TECHNOLOGY MISSION ON OIL CROPS FOR SELF-RELIANCE IN VEGETABLE OILS IN INDIA

Mangala Rai

The Government of India has been concerned about the slow progress in production of oilseeds in the country and the resort to large scale imports 47 million rupees of edible oils in the last five years. Next to mineral oils, edible oils have been the single largest item of import, despite the country's about 19 million ha under oilseeds. In order to solve the problem on a war footing, the Government appointed a Technology Mission on Oilseeds in May 1986, as a task force of all concerned government agencies. On the recommendations of this Mission, the government has approved an integrated policy on oilseeds production, import, distribution and pricing for accelerating self-reliance.

The basic objective of the mission was set in Feb. 1986, when the Prime Minister, in his address at the Indian Agricultural Research Institute, New Delhi, defined the scope and strategy of the mission as follows:

> "One of our biggest problems today in the agricultural sector is oilseeds. We are setting up a thrust Mission for oilseeds production. When we talk of a mission, we mean an exercise starting from the engineering of the seeds and finishing with the finished products of the vegetable oil which could be delivered to the consumer. We would like to put one person in-charge of such a mission with full funding, with no restrictions on him whetner bureaucratic or otherwise. The only limits will be certain achievements which must come within a certain time frame. This will cut across a number of Ministries where we find a lot of hassels and we find our projects getting stalled because the interaction is not smooth enough."

The mission basically adopted a four-pronged strategy as indicated below:

- _firstly_, improvement of oilseeds crop technology for stepping up yields and profit to the farmers;
- _secondly_, improved processing and post-harvest technology which can increase the oil yield from traditional and non-conventional sources of oil, at present about 500,000 tons of oil are annually lost owing to inefficient processing;
- _thirdly_, strengthening services to the farmers, particularly to supply technology, seeds, fertilizers, pesticides, irrigation, credit, etc.; and
- _fourthly_, improving institutions for post-harvest services including price support to farmers and financial and other support to the processing industry.

While devising the strategy, strengths and weaknesses were assessed as follows:

Strength:
- Well-tested strategy which has worked for wheat, rice and cotton.
- A good network of research organizations.
- A well-established infrastructure for supply of inputs and services.
- Proven success of oilseed co-operatives on the Anand pattern.

Weakness:
- eighty-five percent of the oilseed crops are grown in

rainfed lands mostly having poor soils.

- A large majority of oilseed farmers are small and marginal.
- Susceptibility to pests and diseases.
- Technology not as profitable as that of wheat and rice.
- Technology not as profitable as that of wheat and rice.
- Exploitation by middlemen and speculators.

Structure:

To facilitate co-ordinated action, the mission at both the national and state levels has been divided into 4 mini-missions for the 4 important thrust areas. The structure of the National Mission is illustrated below:

	Category	Nodal Dept.	Participating Org.
I.	Crop Production Technology	- Dept. of Agri. Research and Education	- ICAR, Dept. Bio - tech. State Agric. Univrsties.
II.	Post-Harvest Technology	- Dept. of Scientific and Industrial Research	- CSIR, Dept. of civil supplies
III.	In put and Service Support to the Farmers	- Dept. of Agric. and Co-operation	- State Agric. Dept. NDDB, NABARD, NOVOD Board
IV.	Price support storage, Processing and marketing	- Dept. of Agric. and co-operation	- NCDC, NDDB NAFED Dept. Civil Supplies KVIC, NOVOD Board.

Achievements

I. Crop production technology

The mandate to evolve viable, profitable, feasible and easily adoptable crop production and protection technologies for various regions, seasons, situations and cropping systems were vested in the Indian Council of Agricultural Research as an apex body for agricultural research, education and frontline technology transfer in the country. The Council in consultation with its partners identified 136 research activities for 9 annual oilseed crops and coconut and oilpalm which were rated as long-term potential oil yielding plantation crops.

The major emphasis was laid on: a) scaling up yield potential for greater productivity, b) reducing crop duration for fitting oilseeds into multiple cropping systems, c) increasing oil content in the seed to realise higher oil yields *per se*, d) breeding disease and pest resistant varieties for greater stability, and reduction of the cost of production particularly in the endemic areas which are on and off exposed to various biotic stresses, e) exploitation of tissue culture technique in coconut and oilpalm for the production and utilization of disease free promising materials in the shortest time possible, and f) production of adequate quantity of breeder seed of promising varieties to ensure uninterrupted production and supply of quality seed of the best varieties/hybrids available to the farmers to harness their inherent potential. As many as 113 activities were undertaken on varietal improvement with 18 additional activities exclusively for the development of matching agro-production and protection technologies for ensuring cost-effective optimum production. Fifteen research activities were assigned for developing suitable agricultural implements for various field operations and catering to the post-harvest requirements of oilseeds. The research activities on a time scale were devised on a mission mode pattern for 1, 2, 3, 4, 5 and more years. As many as 5, 6, 14, 19, 17 and 55 activities were assigned for completion in respective periods.

During the mission period, as many as 59 promising varieties/hybrids of different oilseeds viz., Groundnut (11), Rapeseed-Mustard (10), Sunflower (9), Linseed (8), Soybean (7), Sesame (7), Safflower (3), Niger (3), Castor (1) were identified/released/notified. The development of these varieties has fulfilled the targets envisaged. Productivity of each of the crops will be enhanced in different regions, seasons, situations and systems few folds, if potential of these varieties is realised exploited, i.e.:

- Groundnut cv. 'Girnar-1' exhibited multiple resistance to foliar diseases and drought and ICGS-11 recorded as much pod yield/ha as 52.72 q under ideal conditions. The average yield of all the newly evolved varieties was at least two fold to the national average yield.

- In rapeseed-mustard, the early (about 75 days) maturing toria variety Bhawani would revolutionize toria calttivation as a catch crop in the major toria growing belt and TL-15 with an average yield of 12.50 q/ha will bring additional area under toria as a summer crop in high altitude areas of Himachal Pradesh. Mustard variety NDR-8501 would go a long way under salt affected soil conditions due to in-built tolerance to salinity and alkalinity. Mustard varieties RH-781 and RH-7361 possess better tolerance to frost which causes serious damage to the mustard crop in frost prone areas. Varieties RLM-514, RH-7361, RH-30 and RH-819 are high yielding and are suitable for Jammu Region of J&K, Himachal Pradesh, Punjab, Haryana and Rajasthan which are the major rapeseed-mustard producing areas in the country. Similarly, 'Vabhav' would go a long way in Uttar Pradesh and Madhya Pradesh which are also important areas for rapeseed-mustard production. For late sowing conditions, varieties Pusa Bold, Vardan, Sharma and RH-7859 are identified for popularizing cultivation of rapeseed-mustard in non-traditional situations. Varieties, RLM-619, RLM-514, Seeta and Vardan are found suitable for different regions in the States of Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu which are non-traditional rapeseed-mustard growing stages.

- The recently released sunflower hybrid, MSFH-17 has produced 16% and 23% higher seed and oil yield over the best hybrid available. LDMRSH-1 and LDMRSH-3 hybrids possess in-built resistnace to downey mildew and are recommended for downy mildew endemic areas of Maharashtra. It is hoped that cultivation of these two hybrids would take care of the deadly disease which was introduced from foreign countries and crippled sunflower cultivation in the region. As the open pollinated varieties of sunflower will continue to dominate in the years to come, the release of early maturing (80-85 days) sunflower population S-55-59 would not only provide an option but also an edge over 'Morden', the only early maturing and most popular variety under cultivation in the country. With the release and notification of these varieties and hybrids now there are ample options available for the farmers for the cultivation of different varieties and hybrids of sunflower depending on their specific needs in a crop which was introduced in the country only about a decade ago.

- For the first time, two double purpose linseed varieties (Gaurav and Jeevan) having fibre and seed yielding capabilities at par to the best fibre and seed types have been released and notified. With this, a long felt dream of 1930's is now fulfilled. Here, it may be mentioned that linseed in India was never used for fibre production and thus the country always remained dependent on fibre import which is considered indispensable in various industries and defence establishments. The first powdery mildew resistant variety, Jawahar-23 and the multiple disease resistant (wilt, rust and powdery mildew) variety Kiran which are released and notified would go a long way in Central and Peninsular regions of the country where these diseases are serious.

- In Soybean, PK-564 exhibited as much yield as 39.39 q/ha with an average productivity of 20.80 q/ha under rainfed situations. Variety PK-472 possessing tolerance/resistance to yellow mosaic virus, bacterial pustules, leaf spots and Girdle Beetle yielded an average of 25.00 q/ha. Because of the several potential varietal options, the area under soybean has started expanding tremendously in conventional and non-conventional regions and seasons. It is hoped that during 1989-90, the area would reach an all time record of 2 million ha with significantly enhanced productivity in a crop whose cultivation was not known about a decade ago in the country.

- Malviya Kusum-305 safflower is appreciated for its proven tolerance to salinity/sodicity. It is expected to cover large area under salt affected soils in the Indo-Gangetic Plains. The two released varieties during the mission period have now reached more than 16 vars which are available for cultivation in different drought prone regions of the country.

- New castors hybrid GCH-4 possessing in-built resistnace to wilt has started revolutionizing castor cultivation in both irrigated and rainfed areas. On an average, it yielded 12.23 and 22.32 q/ha under rainfed and irrigated situations, respectively. However, it recorded 29.27 and 32.07 q/ha under rainfed and irrigated conditions under favourable environments. As compared to the national average yield of 5.37 q/ha, the potential of harnessing the worth of the hybrid is tremendous.

Fertilizer requiremetns, irrigation schedules and various other facts of crop management are standardized for different situations. Efficient intercropping, relay cropping, sequential cropping, *Paira* or *Utera* cropping systems for different crops and regions are stadardized. The production technology package for input-intensive and input-scarce situations are developed. The technology packages for each of the crops were published and widely distributed for their adoption. A number of viable intercropping combinations and efficient crop geometry are worked out and are found to be highly remunerative. The intercropping combinations, if adopted, can stabilize proudction and enhance net monetary returns in biotic and abiotic unfavourable environments.

The management practices are developed for the control of root wilt and Ganoderma disease of coconut. Seven varieties are released and notified in the last three years. These varieties are capable of yielding 2.10 - 2.74 tons of edible oil/ha as compared to 1.6 tons/ha as realised in tall varieties. A number of hybrids from Tall X Dwarf types have shown great promise. The integrated farming systems with coconut are developed where cattle farming is also taken as the integral part of the whole system. This system gave Rs. 20,000 /ha and fuel to the family as against Rs. 14,000/ha with coconut alone. The technology was perfected and tenera hybrids in oilpalm were evolved. These promising materials are under evlaution and have shown yielding ability of about 4 tons/ha of edible oil.

The technology for the production of tissue culture materials in coconut has been standardized. The non-destructive excision of leaflets from the shoot tips has been standardized on seven trees. All these palms have survived and recouped. Callus from leaf base culture was of two types, filamentous and compact. Embryos produced from leaflets ex-plants had a separate shoot pole but a developing root pole. The perfection of the technique for commerical exploitation in coconut is quite cumbersome, tidious and lot of time demanding. Accordingly, the time targetted for the completion of the activity is considered to be further time demanding.

In oil palm, a non-destructive method has been perfected for excising young leaflets from near the shoot apex for in-vitro culture. Through such ex-plants from tenera sources, about 35 in-vitro ex-plants have been transferred to soil. Many more are in the test tubes. Attempt to culture dura and pisifera materials have not been successful. So far callus initiation has been possible from mature ellite palms but embryo genesis has to be achieved. Using ex-plants, about a dozen of plants have been regenerated. However, the response of cultured young inflorescence appears very promising since there is no colour intervention and direct embryo genesis has been observed.

Development of Farm Implements and Machinery

Multi-purpose tool frame (Bullock Drawn): Various designs of tool frame with and without wheels have been developed. The main objective being provision for attaching suitable tillage, sowing and weeding tools as and when desired. The wheeled-types have the advantage of low friction force but at a higher cost. The capacity of the area coverage by a pair of animals is increased by 1½ - 2 times.

Seed drills or seed-cum-fertilizer drills (manual and bullock drawn): Seven designs of seed drills and seed-cum-fertilizer drills were initiated for testing and evaluation of oilseeds (seed rate, 3-5 kg/ha).

The CIAE 3 row seed-cum-fertilizer drill has been recommended for medium size grains like soybean, safflower, sunflower and covers about 0.75-1 ha/day. The unit is commercially available and costs about Rs. 1400-1500. For smaller seeds like mustard 'CIAE two row mustard seed-cum-fertilizer drill was developed. It also covers about 0.75 ha/day and costs approximately Rs. 1000. Besides, Birsa seed-cum-fertilizer drill, IGFRI two-row seed drill and Pantnagar designs are also satisfactory and will be supplied to selected oilseed centres.

Manual weeder: A range of manual weeders have been identified for different regions. Some of these have been released by Release Committee. Most promising designs are from CIAE, Bhopal (Wheel hoe and Peg type), PAU, Ludhiana (Wheel hoe) and TNAU, Coimbatore (Wheel hoe). The cost of these weeders varies from Rs. 125-150. A number of State Agro-Industrial Developemnt Corporations have started commercial production of these designs. The capacity of manual weeders varies from 20 to 110 man-h/ha depending upon weed infestation and soil conditions.

Serrated sickles: These have been perfected and are now commercially available. Efforts are being made to train the farmers in their proper use.

Self propelled vertical conveyer reaper and tractor drawn vertical conveyer reaper: The performance of available vertical conveyer harvest was tried in harvesting oilseed crops like soybean, mustard and linseed with limited success. It is being supplied to oilseed centres for their evaluation.

Soybean harvester: The CIAE Bhopal has developed a tractor drawn side mounted soybean harvester. The machine has been taken up for commercial manufacture by local industries. It harvests soybean in the field in the form of bunches. These are then picked up manually and transported for threshing. The machine can harvest about 3 ha in a day and costs Rs. 15,000. This is considered promising as shattering is a serious problem in soybean.

Multi-crop thresher: Two designs of multi-crop threshers (5 h.p. and 7.5 h.p.) have been developed and perfected by CIAE Bhopal for threshing oilseed crops like soybean, safflower and sunflower. The capacity varies from 200 to 1300 kg/ha depending upon crop and size of power. The basic design is adopted from axial flow with spike tooth threshing cylinder and aspirator-blowers for grain cleaning. The threshers are provided with safe feeding devices. The cost varies from Rs. 10,000 - 12,000. In addition, groundnut threshers are being commercially manufactured but are not very popular. Efforts will be made to select few designs and supply to selected centers for demonstration and popularization.

Groundnut digger (animal drawn): Three designs of animal drawn groundnut diggers have been tested and perfected for popularization. The CIAE design is identical to piped frame of Gujarat supported on two wheels. The implement is suitable for digging groundnut and the pods are manually picked. This can also be used for digging potatoes. The cost of the machine is approximately Rs. 1,200. It can cover about 0.4 ha in a day. TNAU, Coimatore design is similar to CIAE Bhopal except that it is provided with large wheels, a platform for the operator to sit and blade lifting device. CTAE, Udaipur design is basically a modified plough fitted with share and lifter rods. The implement is suitable for soils. The cost may vary between Rs. 300 - 350.

Groundnut decorticator (manual): This is a light weight rocking type manual decorticator for separation of groundnut kernels from the pod. It consists of a hopper and rubbing shoes. The bottom of the hopper is provided with suitable sieves to allow the crushed groundnut to pass through and then winnowed. It can shell about 60-70 kg pods/ha. This is one of the most popular machine. It has already been commercialized by a number of State AIDC's, and costs Rs. 250 - 400.

Breeder Seed Production

During 1984-85, only 2112.24 q of breeder seed of 9 annual oilseeds was produced. In the subsequent years, the production of breeder seed was stepped up as much as

2762.00, 3100.30, 5021.36 and 8600.00 q of breeder seed was produced in respective years. As such, the breeder seed production went up over four fold in a period of 4 years.

II. Post Harvest Technology

The mini-mission addresses itself to the development of suitable post-harvest technology for oilseeds. The objectives are to develop:

- modern integrated processing technology,
- technology for minor and unconventional oil-bearing materials,
- technology for better oil recovery, and
- improvement of ghanis and expeller units and hence the quality of cakes and extractions.

These involves identifying the technological problems associated with oilseeds and oils, and removing these gaps in the technology.

A project on 'Design of Modern Oil Expellers' has been undertaken by the Central Mechanical Research Institute which will bring down the residual oil in the cake from 9-12% to 4-6%. A 20 tons/day capacity is to be made available for users by December 1988 followed by a 10 tons/day capacity unit.

Rapeseed/mustard is the second most important oilseed crop after groundnut but most of the material is crushed without removal of husk. This imparts a dark color to the oil and meal, increases crude fibre in the cake and leaves behind 14-16% unextracted oil. The newly developed expeller takes away the bitter and toxic elements in the expelled oil and meal. The bland high-protein mustard concentrate can be utilized in various protein-rich foods, since its quality is comparable to that of milk protein.

The Central Food and Technology Research Institute (CFTRI) has developed a technology for decortication of sunflower seed which results in 5% more oil. The oil, being wax-free and lighter in color, has better marketability. A plant with a capacity to decorticate 250 kg/hr has been demonstrated.

The MERADO center of CMERI at Luchiana is working on improving the design of the sunflower decorticater developed by CFTRI to reduce the cost of the machine. The improved version will shortly be made available.

Production of crude palm oil with acceptable levels of free fatty acids (FFA) and moisture requires strict field and mill practices and stringent quality control measures. The Regional Research Laboratory, Trivandrum, has developed a mini palm oil extraction mill to produce high-grade raw palm oil, which can be consumed without further processing. This is in view of the fact that small-scale oilpalm plantations may be required in India.

The Regional Research Laboratory, Hyderabad, has developed a process for screw press and pre-press extraction of cotton-seed for edible oil. Although 400,000-500,000 tons of edible oil can be potentially produced out of the available 3 million tons of seed. At present not more than 250,000 tons of oil is produced every year because of inadequate returns on by-products and hence profitable technology has been developed for low-gossypol, high protein cotton-seed meal/flour suitable for human consumption, poultry and pig feed.

III. Input and Service Support to the Farmers

The mini-mission deals with input and service support to the farmers. The strategy is to:

- strengthen the extension system for transfer of technology to the farmers, through the National Oilseeds Development Project (NODP) and the Oilseeds Production Thrust Project (OPTP),
- streamline the production supply and distribution of seeds, fertilizers, pesticides and implements, and
- arrange for distribution of credit through co-operatives, regional/rural banks and commercial banks.

The NODP covers 180 districts in 17 important oilseed-growing states. The government of India covers half the cost of components such as demonstration of improved technology, distribution of seeds and fertilizers, minikits, subsidy to the farmers on seeds, fertilizers, rhizobium culture, plant protection and farm equipment. The project also provides 100% assistance to ICAR for production of breeder seeds for distribution to the states free of cost. Districts with increased production potential have been identified, and emphasis is given to improve the management of various services which would help the farmers to increase oilseeds production. During the 5-years of the Seventh Plan, an outlay of Rs. 170 billion has been provided of which the center's share is Rs. 100 billion.

It will be noticed that 4 oilseed crops contribute about 85% of the total oilseeds production. Keeping this in view, a scheme called Oilseed Production Thrust Project (OPTP) has been initiated since 1987-88 to accelerate the production of 4 major oilseed crops namely: groundnut, rapeseed-mustard, soybean and sunflower. The project provides 100% GOI assistance to the state to strengthen the key components like seed production, plant protection, demonstration, application of sulphur and market support. Under OPTP, and outlay of Rs. 19 million was provided during 1987-88; and Rs. 35 million has been allocated in 1988-89. A total of 246 districts in 17 states, including 151 NODP districts, have been included.

During 1986-87, despite a 20% deficient monsoon over the previous year, the production registered an increase of about 6%. The area under sunflower and soybean in kharif 1987 went up by 40 and 17%, respectively over the previous kharif. In 1987-88, the country witnessed one of the worst droughts of the century, yet the farmers encouraged by the above scheme, took special measures to increase oilseed production which has been 12 million tons. It is hoped that production during 1988-89 would be around 17.5 million tons.

IV. Price Support Storage Processing and Marketing

The mini-mission is charged with the two-fold responsibility of ensuring that, oilseed farmers are given the benefit of price support, and the oilseed industry, whether in the co-operative, public or private sectors improve efficiency of storage, processing and marketing. To this end, the mini mission strives to achieve:

- timely declaration of prices,
- efficient procurement operations, by designated agency,

- expansion and modernization of storage facilities for oilseeds and oil,
- creation and expansions of integrated modern processing facilities in the co-operative sector.
- modernization of existing processing facilities in the private sector, and
- modernization of marketing system and fair price to the consumer.

The mini mission provided all necessary support to ensure declaration of support prices adequately in advance of the sowing season.

National Agricultural Co-operative Marketing Federation (NAFED) was designated as the agency for implementing the price support scheme, under which the farmer is assured of a pre-determined minimum price for his produce. It was ensured that NAFED made all preparations in time and established its presence in all important mandates well before the arrivals. This lent, much needed support to stabilize the market sentiment. Actual procurement under the price support scheme has, however, not become necessary during the last 2 years in view of the ruling high prices.

In the co-operative sector, the National Co-operative Development Corporation (NCDC) and the National Dairy Development Board (NDDB) are the two important agencies to promote efficient processing and storage. For each of these organizations, specific activity milestones on a quarterly basis were specified and their progress continuously monitored.

As mission worked in a harmonious manner, the production target set for 1989-90, 18 million tons of oilseeds, is expected to be achieved. The import of oil is likely to be less than half the same could effectively be phased out within the coming 3-4 years. It is hoped that by the end of the century a production of 26 million tons of oilseeds would be achieved.

OILSEEDS RESEARCH IN INDIA: NETWORK, ITS SET UP, ORGANIZATION, PAST ACHIEVEMENTS AND CURRENT RESEARCH THRUSTS

V. Ranga Rao

Organizational Structure Of Indian Oilseeds Network

The annual oilseeds constitute very important agricultural commodity in India: at current levels they account for about 11% of gross cropped area and 10% of the value of the aggregate output from agriculture. India holds unique position in the world both in terms of acreage as well as the diversity of oil yielding species grown and the crop growing situations. Barring some sporadic and fragmented research efforts under either State/Centrally Sponsored Programmes oilseeds received little or no research support until late 60's. Realizing the stagnation in the production of oilseeds coupled with violent fluctuations in space and time, low per hectare yields and the multiplicity of production of problems plaguing the oilseeds front in the country and as a sequel to the recommendation of the sub-committee set up by the Government of India, the ICAR established the All India Coordinated Research Project on Oilseeds (AICORPO) in 1967. The project which marks a significant milestones in the history of oilseeds research and development in the country initially started with five oilseed crops namely, groundnut, Brassicas, sesame, linseed and castor and a modest outlay of 10 million rupees spread over 32 research centres. Over the years the AICORPO underwent rapid growth both in terms of research network as well as manpower engaged, investments and crops handled; today, the project has a network of 63 centres with 101 problem oriented multidisciplinary teams spread over 17 states covering 8 oilseed crops/crop commodities. The Directorate of Oilseeds Research, Hyderabad (established in 1977) which is headquarters of the AICORPO is backed up by 7 crop coordinating units one each for principal crop(s0/crop commodities viz. groundnut (Junagadh, Gujarat), Rapeseed-Mustard (Hisar, Haryana), Sesame & Niger (Jabalpur, Madhya Pradesh), Safflower (Solapur, Maharashtra), Sunflower (Bangalore, Karnataka), Castor (Hyderabad, Andhra Pradesh) and Linseed (Kanpur, Uttar Pradesh) located in the heart of their respective crops cultivation in monitoring and coordination of the oilseeds research programmes in the country. The headquarters of crop coordinating units also serve as active centres of genetic resource conservation. Documentation, evaluation and exchange in their respective crop/crops. Besides, there is also a National Research Centre for groundnut (established in 1979) Junagadh to provide the needed basic research support to the AICORPO.

Major Research Achievements

The last two decades of organized and systematic research in oilseeds has indeed paid rich dividends. Breeding researches launched both within and outside the project since their inception have resulted in the release/identification of as many as 200 and odd improved varieties/hybrids of either specific regional or multi state importance in different annual oilseed crops. Included in this are also a number of commercial hybrids developed in crops like sunflower and castor. As compared to their traditional counterparts the new generations of varieties/hybrids are high yielding and carry in some cases one or the other superior agronomic attributes such as in-built tolerance/resistance to major insects/diseases, early maturity, photo-thermo-insensitivity, etc. Of specific importance among these is the development of early maturing varieties of groundnut, sesame, sunflower, rapeseed and soybean which made introduction of oilseeds in double and multiple cropping systems possible in several rainfed and irrigated areas.

Besides evolution of new varieties/hybrids in different oilseed corps, research efforts so far made have also opened a wide range of new avenues for improving area, production and productivity of oilseed crops and minimize instabilities so often associated with their cultivation. Based on the efficient areas and situations identified for cultivation of different annual oilseeds in the country possible areas of diversification of prevailing crop base, feasible and viable inter and sequential cropping systems with oilseeds either as base or inter/mixed/sequence or relay crop have also been perfected for each of the crops and crop growing situations in the country. The exploitation of oilseeds in sole/sequence/relay and inter and mixed cropping systems in all their proven and efficient areas of cultivation is expected to lead to sizeable increase in their acreage and production.

Yet another significant output of the past researches is the refinement of agro-production and protection technologies required to derive the full potentials of oilseeds in sole, sequential and intercropping systems. Considering the economy of the bulk of the farmers and the prevailing farming practices, major emphasis on the agronomic front is laid on cost reducing or simple low-cost technologies such as optimal planting time, precession and timeliness of crucial operations like weeding, minimal irrigation, fertilizer application; seeding rates, devices, quality seed, scientific crop rotation, interculture, etc. Research data so far available from different crops and regions show that farmers can easily raise their yields and incomes from oilseeds in both rainfed and irrigated areas by as much as 20-50% just by switching over to such simple low-cost practices.

Apart from development of fertilizer schedules, their rate, time and method of application, integrated management practices for minimizing losses from insect pests and diseases oilseeds researches in the country also established crucial role of life saving/minimal irrigation at sensitive stages of crop growth or whenever soil moisture and rainfall conditions warrant. Crops which benefited from such life saving or minimal irrigation yielded additional yields to the tune of 30-40% over control plots. The inherent low water requirements of oilseeds and their higher demonstrable yields per unit area, time, input and water has infact paved way for increasing popularization of oilseeds in place of those requiring too frequent and excessive irrigation such as winter/summer groundnut in place of rice; safflower and rapeseed-mustard in place of wheat etc. in the command areas of various major and minor irrigation projects particularly under conditions of limited water availability.

Results of on-farm trials available from different agro-ecological and crop growing situations highlight the vast untapped yield reservoir that exists even with the currently recommended improved varieties and production and protection technologies generated. Based on the demonstrable potentials of presently available crop varieties and technologies increasing thrust in the country's oilseeds development programmes is laid on:

1. Exploitation of available agro-production and protection technologies and crop varieties;
2. Diversification of crop base with more profitable and efficient oilseed crops in different areas/situations;
3. Introduction of oilseeds as intercrops in cereals, millets legumes and non-legumes to improve yield and returns from drylands;
4. Exploitation of feasible and viable oilseed-based double and multiple crop sequences: harnessing the superior potentials of oilseeds under limited irrigation.

Considering the crucial role of quality seed which is a basic input the project has also been laying considerable emphasis on production of basic and breeder seed of various annual oilseed crops. During 1988-89 the project has produced as much as 1061 tons of breeder seed which include 755 tons of groundnut; 5 tons of rapeseed-mustard, 27 tons of sunflower; 254 tons of soybean and 20 tons of other oilseeds.

Major Research Thrusts/Priorities In The On-Going Programs

While no doubt researches have made significant advances for improving area, production and productivity of oilseeds there are nevertheless, a multitude of unsolved problems which continue to limit the realization of the full genetic potentials of oilseeds and elude breakthroughs on the productivity front. High vulnerability of most of the currently available cultivars of different oilseed crops to various biotic and abiotic stresses and the associated instability in acreage, production and productivity in space and time is one of the most important constraints which calls for immediate attention. Besides this, there are a number of other research gaps viz. low per hectare yields coupled often with low biological efficiency, lack of appropriate post harvest technologies, non-exploitation of biocontrol agents (predators, parasites, fungi, viruses, etc.) in pest and disease management, low tempo of research in the quality of oil and oilseed extractions, etc. To tackle these and numerous other productivity problems, the on-going researches have been reoriented with special thrusts on the following areas:

1. Development of high yielding varieties/hybrids with required maturity duration and inbuilt resistance/tolerance to major biotic/abiotic stresses.
2. Refinement of agronomy of oilseeds in diverse agro-ecological and crop growing situations both traditional and non-traditional areas, seasons and situations with emphasis on efficient management of costly inputs like fertilizers, irrigation on systems approach for maximizing returns per unit input, time and area.
3. On-farm researches for bridging the untapped yield reservoirs.
4. Refinement of seed production agronomy.
5. Development of efficient post harvest technologies.
6. Genetic resource conservation, evaluation, documentation and utilization.
7. Improvement in seed oil content and its quality;
8. Exploitation of hybrid vigour in crops such as safflower, rapeseed-mustard, sunflower and castor, and
9. Basic researches in priority areas.

GROUNDNUT AND THE OILCROPS NETWORK

S.N. Nigam

Groundnut is grown on 20 million hectares in about 103 countries with a total production of 21.5 million tons. The approximate limits of present commercial production are between latitudes 40° N and 40° S. Most groundnuts are grown in Asia followed by Africa, North and Central America, and South America. Average yields of groundnut in Asia and Africa are low in comparison with those from the USA and much lower than the potential yield of over 10 t/ha reported from research plots. Major constraints to groundnut production are damage by diseases and pests, unreliable rainfall patterns with recurring droughts, nutritional stresses, poor agronomic practices with limited use of fertilizers, and lack of high yielding adapted cultivars. Groundnut crops are found in farms at all levels of development - from bush clearings to the highly mechanized high input outfits in USA. The productivity varies accordingly from 0.3 t/ha to 10 t/ha. The key to high yields is identifying and overcoming constraints to production.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) carries out research on groundnut at three Centers. Groundnut research at ICRISAT Center (IC), Patancheru, India started in 1976. A regional program for Eastern and Southern Africa (SADCC-IC) was established in 1982 in Lilongwe, Malawi. A second regional team was located in 1986 at ICRISAT Sahelian Center (ISC), Niamey, Niger. The first phase of the SADCC-IC program at Malawi was funded by the IDRC.

The problems of global importance are studied intensively at ICRISAT Center. Problems more specific to particular regions are worked on in regional programs or through cooperative research with national programs. The three ICRISAT programs work closely with each other. There is regular flow of improved germplasm among the programs.

IC program interacts with the national programs in Africa through the respective regional program. In Asia, it operates through Asian Grain Legumes Network (AGLN) of the ICRISAT Legumes Program. Cooperative linkages also exist with other international organizations working on groundnuts such as Peanut CRSP, IRHO, FAO, IDRC, USAID, Winrock International, etc.

At ICRISAT, we integrate plant breeding, plant pathology, entomology, microbiology, physiology and cytogenetics research to produce high-yielding adapted cultivars with stable resistance or tolerance to the major stresses presently limiting production. Groundnut scientists cooperate with economists, cropping system specialists, and agronomists to develop crop management systems applicable to the small farmers. The world collection of groundnut and wild *Arachis* germplasm provides the basis for improvement of the crop.

Priority research areas in the crop improvement are foliar diseases (rust, late leaf spot, and early leaf spot), diseases caused by soil-borne fungi (pod rots and aflatoxin contamination), virus diseases (bud necrosis, rosette, peanut mottle, peanut stripe), insects (jassids, thrips, leaf miner, *Spodoptera*), nutrient stresses (Iron and Calcium), and drought. Based on biotic/abiotic stresses and agro-climatological data bases, investigations include identification of the important combinations of stresses and the required maturity duration in different regions. We aim to develop early, medium, and long duration varieties/populations with resistance to relevant combinations of stress factors that will fit well into the existing farming systems and will meet the end use and consumer's preference.

In addition to supplying early generation populations and germplasm lines, the IC Program offers international trials of advanced generation lines to our cooperators. The regional programs carry out regional trials. International trials in Africa are sent through the regional programs.

Regional programs are regularly fed with new elite material from ICRISAT Center. Promising lines from this material are included in regional yield trials. International trials are normally conducted for two seasons/years before they are reorganized. Data obtained from our cooperators are analyzed and summarized in a booklet for each international trial. Copies of these reports are sent to cooperators to give them an idea of the performance of these trials in other countries. After cooperators have identified promising lines, we often support them on request with supplies of bulk quantities of seed of these lines.

ICRISAT programs organize regular workshops and training courses for the benefit of groundnut research workers. In Asia, these activities are coordinated by the AGLN.

OILCROPS PRODUCTION IN ETHIOPIA CURRENT STATUS AND FUTURE PROSPECTS

Seme Debela

Oilcrops Production in Ethiopia: An Overview

Ethiopian farmers traditionally produce several types of oilcrops.

The aggregate land area under these crops and their total production over the last five crop seasons are as follows:

	Area	Production		Oilcrops as percent of total	
Crop season	('000 ha)	('000 tons)	t/ha	Cult. area	Production
1984/85	273.5	144.5	0.53	4.4	2.9
1985/86	290.5	165.2	0.57	4.5	2.9
1986/87	239.6	158.9	0.66	3.7	2.3
1987/88	212.6	132.9	0.63	3.4	1.9
1988/89 (est.)	383.1	250.2	0.65	5.4	3.4

The current crop season appears to be the most favorable for oilcrops production, as over 250,000 tons are expected from about 383,000 hectares of land. Average productivity at 0.65 t/ha for this season also appears to be reasonably high relative to the other seasons.

The total land area allocated to these crops belies their importance since these are the most important source of fats in our diet. It is estimated that oilseeds provide something like 30 cal/person/day. The balance of the fat needs come from animal sources.

Oilseeds are also economic crops since both the seeds and the cakes from oil extraction are exported to generate foreign exchange for the country. At its peak (1975) oilseeds export accounted for 19% of the total export value. This is exceeded only by coffee, which accounted for 25% of the export value for that year. In 1984/85, however, oilseeds export has dwindled drastically, representing barely 2% of the national export value. In terms of international trade in oilseeds, Ethiopia's export in 1986 represented 0.6% of total world trade in oil seeds.

The Ethiopian farmers grow several oilcrops and the most important of these are as follows:

Nigerseed (noug)

This is the most important oilcrop grown by farmers and is mostly used to satisfy domestic needs. It is normally grown under mid-altitude conditions, especially in heavy soils suffering from impeded drainage. This crop accounted for almost 50% of the total oilseeds production in 1987/88 crop season. Future prospect for this crop is bright, since in relative terms it is projected to account for about 41% of total oilcrops production by 1993/94.

Linseed

This is the second most important oilcrop and is predominantly used for local consumption, although a substantial amount is exported in some years. It is normally grown under highland conditions and on well drained soils. This crop accounted for a little over 30% of the total oilcrops production in the country in the 1987/88 crop season. In absolute terms, production will increase in the coming years, accounting for about

25% of total oilcrops production.

Rapeseed/Mustard

This is the third most important oilcrops grown in the country, although it accounts for a much smaller cultivated area compared to niger seed and linseed. This is also a highland crop grown under well manured land, usually close to dwellings. Large scale production of this crop, especially in state farms, is gaining momentum. In 1987/88 the total production of this crop accounted for no more than 5% of the total oilcrop production, while this reached almost 12% in the 1988/89 crop season. This relative level is projected to hold in the coming five years.

Groundnut

This is a crop of the warmer medium to low altitude areas and is grown mostly for domestic use. It has never accounted for more than a modest amount (about 7% in 1988/89) of the total national oilcrops production. Future prospect for increased production is limited, probably reaching no more than 10% in the next five years.

Sesame

This is actually a traditional export crop, although it is also widely used locally. It is a crop of the low altitude areas, largely grown under marginal environmental conditions. In the 1988/89 crop season, it accounted for only 6% of total oilcrop production. In terms of foreign trade, it accounted for almost 70% of export value of all oilcrops in the 1986/87 season. Future projection of sesame production is not very bright, probably reaching no more than 8% in the coming five years.

Sunflower

This has never been an important oilcrop nationally, although it has some regional importance particularly under large scale production by mechanized state farms. Even its future projection is not bright, as the crop may never account for more than 5% of total oilcrop production.

Others

Other notable oilcrops grown in smaller amounts are safflower and castor. But these are so insignificant, in terms of quantity, that they are not even shown in the national crop production plan for the next five years.

It would be useful to indicate the overall anticipated or rather projected increase in oilcrops production in the coming five-year plan period. The total production of niger seed, linseed, rapeseed/mustard, groundnuts, sesame and sunflower is about 157,000 tons in the 1988/89 crop season. The production of these crops is projected to reach 246,000 tons by the end of the plan period (1993/94). This represents an average annual growth rate of 9.4%. However, in terms of total national production of all field food crops, this represents only 2.5% of the national production.

Production Problems and Constraints

The production of oilcrops is hampered by a large number of constraints, chief among which are briefly described as follows:

Improved varieties

The lack of high yielding and

stress resistant/tolerant varieties is one of the major impediments to raising productivity and total production of almost all of the oilcrops, maybe with the exception of rapeseed/mustard in the last two or three years. The national research system has so far released seven or so rapeseed/mustard varieties, three linseed varieties, three sesame varieties, three groundnut varieties, and one sunflower variety. There is no niger seed variety released so far. However, except for rapeseed/mustard, most of the varieties are not in production for one reason or another. Shattering and diseases rendered the sesame varieties unusable. Diseases are among the major factors responsible for eliminating varieties from production. Lack of sufficient seed is another reason for not getting the newer varieties into production.

Seed multiplication

The national seed production scheme is not developed enough to meet the national seed demand at this time. It is estimated that the potential national seed demand is around 400,000 tons per year and of that about 5,400 tons (1.3%) represent oilseeds. Currently, the Ethiopian Seed Corporation (ESC) produces only selected number of oilcrops and in limited quantities. For example, the ESC's seed multiplication of oilseeds for the 1985/86 season amounted to only 310 tons of rapeseed/mustard and 20 tons of sunflower.

Crop management practices

The lack or unavailability of appropriate biological, chemical and mechanical technologies for managing oilcrops is a serious constraint in the production of oilcrops. Weeds, disease and pest management techniques that fit farmers' circumstances are needed.

Policy issues

Pricing and marketing schemes often work against oilcrops production. For example, our national staple food crop (teff) and niger seed compete for land in identical eco-zones. Because of the market price bias in favor of teff, niger seed loses out under most circumstances.

Oilcrops Research in Ethiopia

The Ethiopian national agricultural research system (NARS) is made up of three full-time research organizations, higher education institutions made up of several universities and colleges and several technical units in development ministries. The Institute of Agricultural Research (IAR), a semi-autonomous public organization under the general guidance of a ministerial board of directors, is by far the largest research unit in the NARS. The IAR accounts for 70% of the agricultural research manpower, 93% of the national agricultural research budget, and 89% of the total research projects in the country.

To all intents and purposes, the IAR is the only significant research service engaged in oilcrops research in Ethiopia. The following are the main IAR research Centers where major research programs in oilcrops are under taken:

Holetta Research Center

This is a highland site with a reasonably good oilcrops production environment. The niger seed, rapeseed/mustard and linseed research projects are based at this center. The center has adequate facilities and manpower for this purpose. The International Development Research Center (IDRC) supported International Oilcrops Network has its base at this center. The research program at this center is well developed and is responsible for the release of several varieties of rapeseed/ mustard, and linseed.

Melka Werer Research Center

The IAR research program in groundnuts and sesame is based here. This is a lowland site where irrigation water is the only reliable source of water for crop production. The program, supported to a good extent by IDRC at this center, has released several varieties of groundnuts and sesame.

Awassa Research Center

This is a mid-altitude site with adequate, even if somewhat erratic, rainfall. Sunflower is the main crop, although local collections and introductions of castor are screened at a modest level. The program here needs strengthening.

Other Research Centers

Several of the IAR research centers serve as trial sites for the oilcrops research programs. Notable among these are the research centers at Adet and Sinana for the highland oilcrops and Abobo and Pawe for the low and medium altitude oilcrops.

Setting up research priorities and research goals are as important as setting up the research program itself. This is especially so for a country like Ethiopia where resources are limited. Priority setting is a complex task and I am not aware of a reliable scientific method for doing it. In our particular case, however, we take serious considerations of the national development plan in our attempt to allocate manpower and budget, although this itself is not an easy task. In any case, the government's current allocation of resources to the agriculture sector is based on the following priorities:

- projects that enhance national food self-sufficiency,
- projects that strengthen national production capability of industrial crops for import substitution purposes and
- projects that help generate foreign exchange.

Obviously, these are important criteria for setting up priorities for research programing. However, we also need to add other factors to enhance our prioritization effort. Among the most important considerations are national production and consumption status, the possibility of making headway in the development of improved technological packages, and the likelihood of farmers' adoption if such technologies could be made available. Please note that we have not developed a scheme for integrating all these criteria in setting up priorities. I indicate these just to show that we try to consider these factors to guide our allocation of resources to research programs in IAR. The exercise is more or less ad hoc.

Based on the above, one can see that none of the mentioned oilcrops meet all factors of prioritization. However, based on the government's stated objective of national food self-sufficiency as a matter of priority, niger seed and linseed will have to be given more emphasis in the coming years. More effort will have to be made on sesame as this is a preferred export crop. A certain amount of resources will continue to be allocated for research work on groundnuts, and to a lesser extent on sunflower.

International Cooperation in Oilcrops Research

The IAR has a long tradition of international cooperation in the development and conduct of agricultural research. It is a recipient of bilateral and multilateral assistance. At the present moment we have close working relationship with no less than ten of the 13 international agricultural research centers under the CGIAR scheme. We also work very closely with non-CGIAR systems like IDRC, which has been and still is supporting our research effort in oilcrops, farming systems and animal production. We are grateful for the assistance and encouragement we get from IDRC.

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THE VEGETABLE OIL/PROTEIN SYSTEM IN KENYA

Summary Report - Phase I

C. Zulberti and J. Lugogo

BACKGROUND

Kenya imported 126,000 metric tons of vegetable oils and fats with a value of US$ 45 million in 1987. The quantity brought into the country is equivalent to 80% of the total local utilization, including that required for soap manufacturing. The amount of foreign currency used represents 2.64% of the total value of imports for home use and is the highest of all foreign exchange expenditures on agricultural commodities.

In spite of the high degree of importation, the consumption of edible fats and oils remains low by international standards. Total consumption of edible fats and oils by the Kenyan population has been estimated at 122,000 MT/year or an average per capita intake of 5.6 kg/year. This is equivalent to 138 kcal/day derived from visible fats. It is also estimated that one and a half times that amount is obtained from invisible fats, giving a total of 345 kcal/day. This means that less than 20% of total dietary energy is supplied by fats, which is below the 25-30% recommended by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO) of the United Nations.

Kenya has suitable agro-ecological conditions to cultivate several kinds of oilseeds, but the quantities harvested remained low. The low volume of local production and processing of oilseeds into vegetable oils and fats for human consumption also results in reduced amounts of protein cake -- the co-product of the oil-extraction industry. Thus the restricted availability of protein cake for the compounding of animal feeds also limits the development of the more commercially oriented livestock enterprises.

The International Development Research Centre (IDRC) of Canada retained the services of a consultant who produced a paper entitled "The Economics of Oilseed Production and Processing for Edible Oil and Protein Cake in Kenya" Presented at the Fourth International Oilcrops Network Workshop in Egerton University on 25-29 January 1988 (Published in IDRC MR205e, A.Omran ed.:55-71).

In that document it is argued that while up to now Kenya has been able to maintain relatively low consumer prices of vegetable oils and fats by importing mostly palm oil, the future foreign exchange bill will reach levels that the country will find difficult to afford.

The high population growth rate in Kenya, the rise in per capita incomes and the urbanization process will all contribute to substantial increments in the demand for oils and fats for direct consumption, as well as for the production of soaps and detergents. At the same time these factors will boost the demand for protein cake as a result of higher consumption levels of livestock products and more commercial techniques of producing them. The combined effect of all these forces will result in a significant increase in the demand for foreign exchange, especially during peak price periods on the highly volatile international market.

The outlook for local production of raw materials remains bleak because the low consumer prices result in low producer prices for oilseeds, making their cultivation insufficiently remunerative for farmers to be interested.

The paper identified the need for a comprehensive study of the oil and fats industry, its backward and forward linkages, and the direct and derived demand for its products, in order to make conclusive recommendations on how to deal with an increasing import bill and lack of sufficient local production.

Egerton University initiated a four-stage program to investigate the economic and technical feasibility of oilseed production and processing for edible oils and protein cakes in Kenya and, thereby, to develop the industry.

The four stages are:

1. A preliminary review of information pertaining to the oil-protein system; consultation with potential Kenayan university researchers, government officials and industry representatives; and the formulation of a proposal to carry out a comprehensive investigation of the various components of the existing system in the next stages (November 1987 to April 1988);
2. A more detailed diagnostic study of the various components of the oil/protein system with a view to identifying the key points for technical and policy intervention and specifying, with respect to the foregoing, a program of in-depth research to be implemented during the next stages (May 1988 to August 1988);
3. In-depth field research relating to those technical or policy interventions considered necessary and sufficient to develop the oil/protein system as an efficient and equitable sub-sector (September 1989 to August 1992);
4. Implementation of various recommendations based on the results of the field research (January 1989 onwards).

The first stage led to the preparation of a project proposal for the Vegetable Oil/Protein System (VOPS) in Kenya Phase I, which was also financed by IDRC. The present document is a summary of the results achieved during this phase.

OBJECTIVES

The objectives of the program were delineated as follows.

General Objective

To characterize the oil-protein system in Kenya with the purpose of identifying key research interventions that could lead to the removal of constraints to local oilseed production, and the processing and utilization of edible oils and protein cakes.

Specific Objectives

- To specify the structural characteristics of the oil/protein production system in Kenya, the linkages between the various components and the quantitative flows between them;
- To determine the farming production systems which include oilseeds, and how they are influenced by the socio-economic environment;
- To describe the technological characteristics of each component, its use of the factors of production and its contribution to value added;
- To find out the present level of

consumption and estimate the future demand of vegetable oils, fats and protein cakes as derived from the dairy, poultry and pig industries;

- To define the policy instruments which influence the oil/protein system, determine the mechanisms for setting them and estimate their quantitative impact;
- To identify, assess and assign priorities to specific areas of research leading to the removal of constraints to local oilseed production and processing into edible oils and protein cakes; and,
- To prepare a project proposal for a subsequent phase which will include those areas of research with highest national priority and expected pay off to the Kenyan economy. The proposal is to be presented to donors for financing.

METHODOLOGY

The work was carried out by seven groups of professionals from Egerton and Nairobi Universities; the Kenya Agricultural Research Institute and Kenya Industrial Research and Development Institute; the Ministries of Industry, Agriculture, Livestock Development and Planning and National Development; and the private sector comprising representatives for the Unga Group of Companies and Oil Crop Development Ltd.

The groups were assisted by 14 Egerton University diploma holders as research assistants.

As the Principal Investigator Professor Juma Lugogo, Deputy Vice-Chancellor for Research and Extension at Egerton University, was the overall coordinator of the project, and Dr. Carlos Zulberti acted as consultant.

Each of the working groups was led by a professional from various institutions, Table 1.

Each of the groups depicted in Figure 1 prepared an individual report based on the information obtained from secondary sources and the survey data gathered from the field through questionnaires and interviews. The reports of the individual groups will be published in the Egerton University Vegetable Oil/Protein System Working Paper Series.

In this summary report, therefore, the results will be organized according to the specific objectives presented in the proposal, as mentioned above.

Table 1. Working groups

Components	Group Leader	Institution
Oilseed production	Dr. M. W. Oggema	Kenya Agricultural Research Institute
Oils and Fats Industry and Consumption	Dr. M. Odhiambo	University of Nairobi
Animal Feed Industry	Mr. P. Bartilol	Ministry of Livestock Development
Dairy Production and Consumption	Dr. P. Karau	Egerton University
Poultry and Pig Production and Consumption	Mr. C.M. Gichogi	Ministry of Livestock Development
Policy Environment, International Markets and Future Demands	Dr. K. Gitu	Ministry of Agriculture
Rural Processing and Consumption	Mr. S.S. China	Egerton University

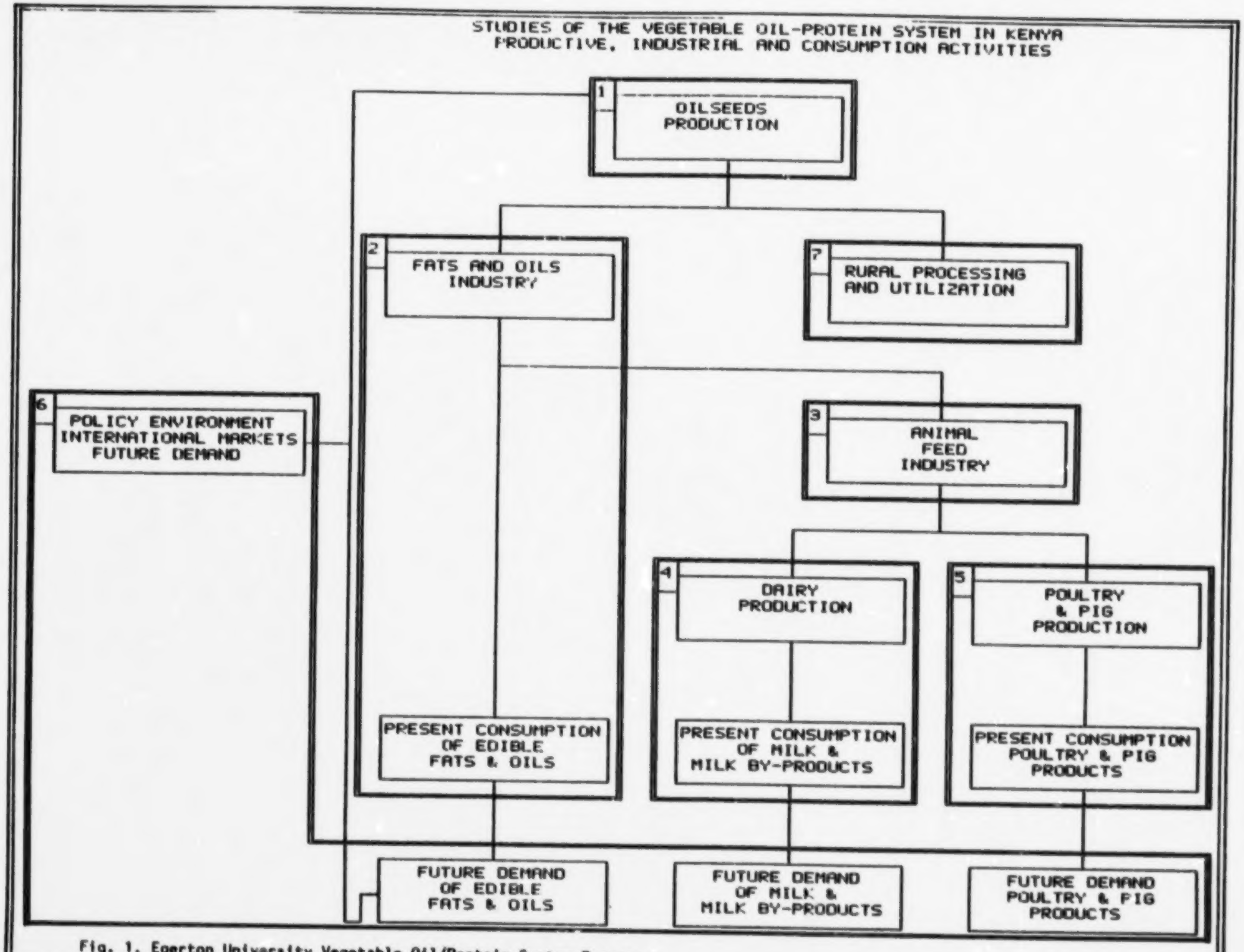
STUDIES OF THE VEGETABLE OIL-PROTEIN SYSTEM IN KENYA
PRODUCTIVE, INDUSTRIAL AND CONSUMPTION ACTIVITIES
1
OILSEEDS PRODUCTION
2
FATS AND OILS INDUSTRY
7
RURAL PROCESSING AND UTILIZATION
6
POLICY ENVIRONMENT INTERNATIONAL MARKETS FUTURE DEMAND
3
ANIMAL FEED INDUSTRY
4
DAIRY PRODUCTION
5
POULTRY & PIG PRODUCTION
PRESENT CONSUMPTION OF EDIBLE FATS & OILS
PRESENT CONSUMPTION OF MILK & MILK BY-PRODUCTS
PRESENT CONSUMPTION POULTRY & PIG PRODUCTS
FUTURE DEMAND OF EDIBLE FATS & OILS
FUTURE DEMAND OF MILK & MILK BY-PRODUCTS
FUTURE DEMAND POULTRY & PIG PRODUCTS

Fig. 1. Egerton University Vegetable Oil/Protein System Program.

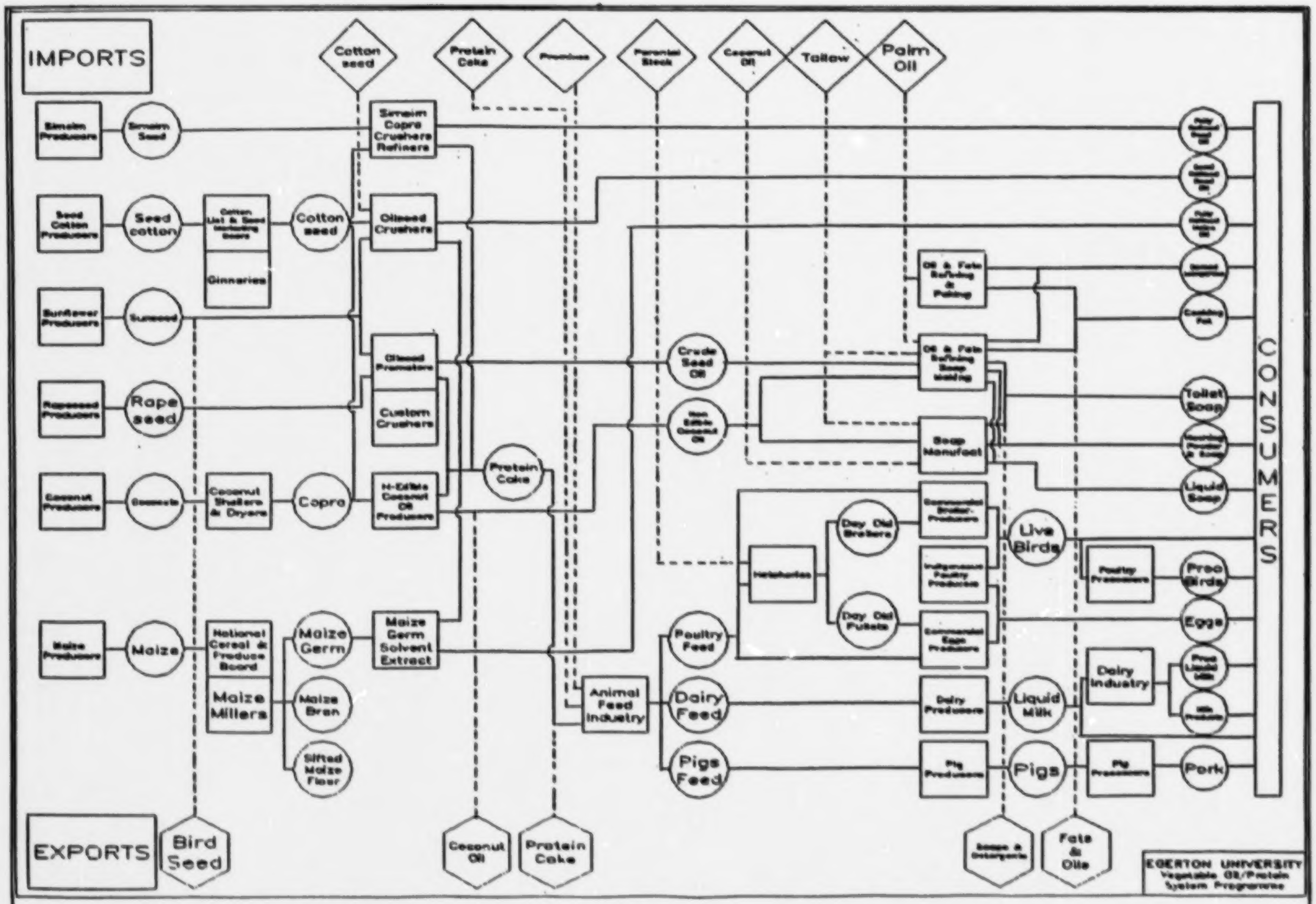
IMPORTS
Cotton seed
Protein Cake
Parental Stock
Coconut Oil
Tallow
Palm Oil
Simsim Producers
Simsim Seed
Simsim Copra Crushers Refiners
Seed Cotton Producers
Seed cotton
Ginneries
Cotton seed
Oilseed Crushers
Sunflower Producers
Sunseed
Oilseed Promoters
Rapeseed Producers
Rape seed
Custom Crushers
Coconut Producers
Coconuts
Coconut Shellers & Dryers
Copra
N-Edible Coconut Oil Producers
Protein Cake
Maize Producers
Maize
National Cereal & Produce Board
Maize Millers
Maize Germ
Maize Bran
Sifted Maize Flour
Maize Germ Solvent Extract
Crude Seed Oil
Non Edible Coconut Oil
Oil & Fats Refining & Packing
Oil & Fats Refining Soap Making
Soap Manufact
Cooking Fat
Toilet Soap
Liquid Soap
C O N S U M E R S
Animal Feed Industry
Poultry Feed
Dairy Feed
Pigs Feed
Hatcheries
Day Old Broilers
Day Old Pullets
Commercial Broiler Producers
Indigenous Poultry Producers
Commercial Eggs Producers
Dairy Producers
Pig Producers
Live Birds
Liquid Milk
Pigs
Poultry Processors
Dairy Industry
Pig Processors
Proc Birds
Eggs
Proc Liquid Milk
Milk Products
Pork
EXPORTS
Bird Seed
Coconut Oil
Protein Cake
Soaps & Detergents
Fats & Oils
EGERTON UNIVERSITY
Vegetable Oil/Protein
System Programme

Fig. 1. The Vegetable Oil/Protein System in Kenya - 1987.

RESULTS

Objective 1

To specify the structural characteristics of the oil/protein production system in Kenya, the linkages between the various components and the quantitative flows between them.

The basic structure of the oil/protein system in Kenya, as far as it has been analyzed, is depicted in Figure 2. The quantitative flows are presented in Tables 2 and 3.

Oilseed Production

Four oilseed crops are grown in Kenya for the production of vegetable oils: sunflower, sesame, rapeseed and coconut. Two other oils are locally obtained -- from cottonseed as the by-product of the maize-milling industry.

White-seeded varieties of sunflower have been cultivated for many years in Kenya for exports as bird seed, and about 700 MT were exported during 1987. The oil content of these varieties is, however, insufficient for economic oil extraction. Black-seeded varieties and hybrids were introduced in the early seventies in order to boost production of seed with a high oil content, but without achieving the expected results.

The area under sunflower in Kenya in 1987 was estimated at 42,000 ha, with an average yield of 300 kg/ha for a total production of 12,600 MT. The amount of oil and cake obtained was estimated at 3,800 MT and 7,900 MT, respectively.

Rapeseed was introduced relatively recently. In 1987 the area cultivated was estimated at 4,700 ha with yields of 770 kg/ha and total production of 3,600 MT of seed. The oil obtained after processing was estimated at 1,400 MT and the cake at 2,000 MT.

Sesame (simsim) originated in East Africa. It has been grown for many years at the coast and in the western part of Kenya. It has been used as seasoning, in cooking and in the preparation of confectionery, thereby making an important contribution to the invisible consumption of oils and fats. It was estimated that 4,600 ha were cultivated with simsim during 1987 giving a yield of 780 kg/ha for a total production of 3,600 MT of seed. It was further estimated that 50% was home consumed and used for confectionery, while the rest was utilized for oil extraction with a production of 700 MT of oil and 800 MT of cake.

Coconuts are grown at the coast for direct consumption and for industrial use. The processing operations, including husking, shelling, and drying of the "meat" (endocarp) of the nuts result in the production of copra, the raw material for the extraction of coconut oil. The oil so obtained by several small processing plants is used by the same firms for their own manufacturing or is sold to other companies involved in soap making. Recently, Ufuta Ltd. has constructed a refining plant in Mombasa which has started to produce coconut oil for human consumption.

The area planted with coconuts in 1987 was estimated at 42,000 ha, with a yield of 1,600 kg/ha, resulting in a yearly production of 67,200 MT of nuts. It was further estimated that 14,000 MT were home consumed, 7,000 were marketed as green and dry nuts and 46,200 MT were used for industrial purposes, resulting in 8,500 MT of copra yielding 5,400 MT of coconut oil. A similar amount of oil was used locally after the exportation of

Table 2. The vegetable oil/protein system of Kenya -1987, Production

Description	Unit	Sesame	Sunflower	Rapeseed	Coconut	Cotton	Maize	Total
Area cultivated	ha	4,600	42,000	4,700	42,000	56,000	1,200,000	
Yield	kg/ha	780	300	770	1,600	340	1,800	
Total Production	MT	3,588	12,600	3,619	67,200	19,040	2,160,000	
Home Consumption	MT	1,100			14,000		1,080,000	
Local Markets	MT				7,000		428,000	
Other Uses	MT	1,000						
Local Use	MT	2,000	0	0	21,000	0	1,508,000	
Marketing Boards	MT					19,040	652,000	
Reserved in Stock	MT						242,000	
Industrial Use	MT	1,588	12,600	3,619	46,200	19,040	410,000	
Coeff. Principal products	MT					33%	78%	
Principal Product	MT					6,283	319,800	
Coeff. Other products	MT						13%	
Other Products	MT						53,300	
Coeff. Oil Bearing Material	MT				18%	64%	7%	
Oil Bearing Material	MT	1,588	12,600	3,619	8,469	12,186	28,700	
Retained for Planting	MT					3,656		
Processed for Oil	MT	1,588	12,600	3,619	8,469	8,530	28,700	
Coeff. Oil	%	45%	30%	40%	60%	18%	17%	
Coeff. Cake	%	50%	63%	55%	35%	80%	82%	
Solvent Extraction Plants								
Quantity Handled	%						100%	
Oil Produced	MT						4,879	
Cake Produced	MT						23,534	
Expellers and Semi-Refiners								
Quantity Handled	%		30%			100%		
Oil Produced	MT		1,134			1,535		
Cake Produced	MT		2,381			6,824		
Promoter & Custom Expellers								
Quantity Handled	%		70%	100%				
Oil Produced	MT		2,646	1,448				
Cake Produced	MT		5,557	1,990				
Expellers and Refiners								
Quantity Handled	%	100%			5%			
Oil Produced	MT	715%			254			
Cake Produced	MT	794			148			
Expellers Non-Edible Oil								
Quantity Handled	%				95%			
Oil Produced	MT				4,827			
Cake Produced	MT				2,816			
Oil Produced	MT	715	3,780	1,448	5,082	1,535	4,879	17,438
Cake Produced	MT	794	7,938	1,990	2,964	6,824	23,534	44,045

Egerton University Vegetable Oil/Protein System Program.

Table 3. The vegetable oil/protein system of Kenya - 1987, Production, imports, Exports and Consumption

Description	Unit	ses-ame	Sun-flower	Rape-seed	Coco-nut	Cott-on	Maize	Palm	Tallow	Soya-bean	Fish meal	Others (1)	Oils Fats processed	Non class	Total
Oil Produced	MT	715	3,780	1,448	5,082	1,535	4,879								17,438
Oil imported	MT				239			124,464	5,182	465		942	4,436		135,728
Oil Exported (Raw Mat)	MT				(320)										(320)
Total Available Oil	MT	715	3,780	1,448	5,001	1,535	4,879	124,464	5,182	465	0	466	4,436	0	152.846
Cooking Fats															
Quantity handled	%							80%					30%		
Prod. Coeff.	%							95%					95%		
Produced	MT							94,385					1,261		95,646
Exported	MT													(1,314)	(1.314)
Total consumed	MT														94,332
Margarines															
Quantity handled	%		20%	20%				12%				50%	20%		
Production coeff.	%		93%	93%				93%				93%	93%		
Produced	MT		706	270				13,940				217	828		15,961
Exported	MT													(194)	(194)
Total Consumed	MT														15,767
Liquid Oils															
Quantity Handled	%	100%	80%	80%	5%	100%	100%			100%		50%	20%		
Production coeff.	%	100%	89%	89%	100%	100%	100%			89%		89%	100%		
Produced	MT	715	2,688	1,029	250	1,535	4,879			413		207	887		12,604
Exported	MT	(20)	(20)											(192)	(232)
Total Consumed	MT	695	2,668	1,029	250	1,535	4,879			413		207	887	(192)	12,372
Soap & Detergents															
Quantity Handled	%				95%			8%	100%				30%		
Production coeff.	%				162%			162%	162%				162%		
Produced	MT				7,674			16,085	8,371				2,150		34,279
Exported	MT													(3,888)	(3,888)
Total consumed	MT														30,391
Oil Protein cakes															
Produced	MT	794	7,938	1,990	2,964	6,824	23,534								44,045
imported	MT					328				755	2,057				3,139
Exported	MT				(1,032)	(2,540)									
(3,572)															
Total consumed	MT	794	7,938	1,990	1,932	4,611	23,534			755	2,057				43,612

(1) Rape-Colza and Mustard Oils

Egerton University Vegetable Oil/Protein System Program.

320 MT to Rwanda and Uganda and an importation of 184 MT from Thailand. Of the 3,000 MT of copra cake obtained, 2,000 MT were used as animal feed and the other 1000 MT were exported to the Netherlands.

Maize germ is also an important source of liquid edible vegetable oil. It is obtained by solvent extraction of the by-product of the milling of whole maize. The maize goes through the National Cereals and Produce Board (NCPB) and is milled for the production of sifted maize meal by the commercial millers. The production of maize meal is estimated at 320,000 MT which generates 53,000 MT of maize germ and 29,000 MT of maize bran as by-products. The maize germ is used for oil extraction, producing 4,900 MT of maize oil and 24,000 MT of maize-germ cake. The maize bran is used as the main energy source (carbohydrate) in the production of animal feeds.

Cottonseed, which is obtained after ginning seed cotton to obtain cotton lint, is another important by-product utilized in the production of oil. At present, all seed cotton produced in the country is bought through agents by the Cotton Lint and Seed Marketing Board (CLSMB) who send it to the ginneries for ginning. The cotton lint obtained is sold by CLSMB to the textile industry and the cottonseed to the oil extractors, after setting aside some seed for the next planting season.

In 1987, the area planted with cotton was estimated at 56,000 ha, resulting in a production of 19,000 MT of seed cotton. After ginning, 6,300 MT of cotton lint and 12,000 MT of cottonseed are obtained. Part of the cottonseed (3,700 MT) was saved as planting material and the rest was used for oil extraction. The amount of oil obtained was estimated at 1,500 MT and the quantity of cake at 6,800 MT, of which 2,500 MT were exported to Denmark and the United Kingdom. There was also an importation of 330 MT of cotton cake, which increased the amount utilized in the country to 4,600 MT.

Oil Extraction

The plants involved in the oil-extraction industry can be put into five groups:

1. Solvent extraction plants with full refining capacity, of which there are three in the country, two of them relatively new. The remaining one is old and has spare parts and operational problems. These plants mainly produce maize oil. Their estimated production in 1987 was 4,900 MT.

2. The expeller-type plants which were mainly set up to use cottonseed as raw material. Due to the shortfall in cotton production, they have begun to process sunflower seed. In 1987 these plants processed 8,500 MT of cottonseed and 3,400 MT of sunflower seed to obtain 2,700 MT of oil and 9,200 MT of cake.

3. A sub-group of the expeller-type plants are contracted to provide custom services to the promoters of sunflower and rapeseed. They produced 4,100 MT of oil and 7,600 MT of cake in 1987.

4. The fourth group comprises one plant recently established by Ufuta at the coast. It produces simsim and coconut oils for human consumption, and the production of oil and cake in 1987 did not exceed 1,000 MT of either product.

5. Finally, there are a number of plants at the coast which deal mainly with copra to obtain oil for non-edible purposes. Some

produce soaps themselves and others sell the coconut oil to soap manufacturers. It has been estimated that the plants produced 4,800 MT of coconut oil and 2,800 MT of copra cake in 1987.

Many of the plants are relatively old and some of them were bought second-hand. They require imported spare parts which are sometimes difficult to obtain due to the scarcity of foreign exchange and due to delays in the issuing of import licenses or foreign exchange allocation. Most of them operate substantially below capacity, mainly because they lack sufficient raw materials.

The significant decrease in the availability of cottonseed for processing, coupled with the absence of procurement mechanisms by the processors and poor incentives for the farmers to produce oilseeds, has resulted in the stagnation of the crushing industry. Thus it is unable to keep pace with the constant growth in demand, leading to steadily increasing levels of raw-material and intermediate-product imports.

Oil Refining and Packing

The refining, hydrogenation and packing operation needs to be analyzed separately from the expelling process, mainly because the expelling operations are being performed by different, unrelated companies (with the exception of a few plants that are vertically integrated).

There are some plants which have the capacity to extract and neutralize oil. These plants produce what is called semi-refined oil which, in many cases, is sold directly to the consumers. These plants are located outside Nairobi and handle mainly cottonseed and sunflower. A few plants have full extraction and refining capacity. In this group are the plants that mainly deal with maize germ, simsim and coconut oil for human consumption.

The liquid oils are mostly sold directly by the extracting plants and the total estimated production was 12,000 MT. However, the bulk of the refining and hydrogenation is done by plants which import most of the required inputs as crude and/or refined oil and process it to various degrees to provide the consumer market with cooking fats and margarine. These plants are located in Nairobi and use palm oil as their principal input. They also do their own packing, distribution and promotion. It was estimated that their sales in 1987 reached 95,600 MT of cooking fats and 16,000 MT of margarine.

One of the latter group of companies is also the largest soap manufacturer which buys local coconut oil and imports tallow and other fats for soap production. There are additional soap and detergent manufacturers whose characteristics are unknown at present. The estimated production of soaps stands at 34,300 MT per annum.

Animal Feed Industry

The extraction plants also produced an estimated 44,000 MT of protein cake as a co-product in 1987. The cake is used by the animal feed industry as a protein source in the production of compound feeds.

The animal feed industry can be defined as a by-product industry because most of its inputs are by-products of other enterprises. Most of the energy sources in feeds are derived from the maize and wheat milling industry or from low-quality barley which is unsuitable for brewing. The protein is derived either from the oil-extraction industry or is imported. Thus the industry is a highly dependant one, making it unpredictable and therefore difficult to plan for.

The total production of animal feeds was estimated at 205,000 MT in 1987, of which 113,000 MT was poultry feeds, 67,000 MT was dairy feeds, 19,000 MT was pig feeds and 6,000 MT was other feeds. The compounding is carried out by more than 10 plants, of which one produces close to 60% of the total. The industry imports protein sources such as fish meal and premixed supplements containing minerals, vitamins and antibiotics.

Livestock Industry

The main users of poultry feed are the hatcheries which import breeding stock and produce day-old chicks (for broilers and pullets) and the commercial poultry operations which buy day-old chicks from the hatcheries. At present no information is available on consumption of compound feed by indigenous poultry. However, the survey carried out among poultry farmers showed that they had considerable problems of insufficient supply and quality of feeds.

Dairy feeds are used by farmers who keep the animals in pens most of the time (zero grazing), and as supplement for growing and milking animals. Given the number of grade milking cows in the country (estimated at more than one million) the average consumption of dairy feed per head is very low. This suggests that most producers only use pastures and industrial by-products (e.g. brewer's waste) to feed their animals and do not buy commercially compounded products.

Pig producers (the number of animals in the country is estimated at 70,000) use proportionally more commercially compounded feeds than do other livestock producers. There are two possible explanations for this. Firstly, the animals are not produced for home consumption but are raised for commercial purposes, which requires that producers meet certain quality standards. Secondly, the nutritional requirements of pigs -- especially the requirements for amino acids -- are more demanding than for other livestock and are difficult to meet from on-farm products.

The pig industry suffered a serious setback in 1985 when the parastatal in charge of processing and marketing pork was unable to pay the producers on time. As a result, many of these producers were forced out of production. At present, private entrepreneurs are commercializing pig products, and the industry is recovering.

Objective 2

To determine the farming production systems which include oilseeds, and how they are influenced by the socio-economic environment.

Close to 150 farmers were interviewed in the major oilcrop producing areas of the country -- together with purchasing agents and extension officers -- to identify the production systems and the main limitations to increased production.

It was found that oilseeds are considered secondary crops by the farmers. Other crops, e.g. maize, coffee, tea, beans, sugar, and cotton, are judged as being more important and have priority for land, labour and, if are used, fertilizer allocation. In most cases oilseeds are grown in association with other crops in multiple, relay or rotational-cropping arrangements.

At present, sunflower is the most

important oilcrop in terms of the area cultivated and the specific purpose for which it is being grown. The promotional work done by Oil Crop Development was quite successful in increasing the area planted to sunflower, especially during the time when free seed and technical advice was being provided. However, the recent reduction in the price paid to farmers, introduction of charges for planting seed and the declining technical assistance effort have had negative effects, so that the area planted and the quantity of seed available for crushing has since decreased again. Nevertheless, farmers have expressed an interest in continuing to cultivate the crop -- and even in increasing the area seeded -- if higher prices were offered.

Simsim is not yet an important oilcrop but it could become so. At present it is being produced mostly for direct consumption and not for oil extraction. Due to lack of research aimed at generating improved practices in the cultivation of simsim, the agricultural extension service does not have any specific recommendations to offer farmers. The seed being used for planting is kept by the farmers from the previous year's crop or bought from neighbours. No selection is being carried out. The potential for improving yields by identifying and selecting appropriate lines from the existing diversified genetic material, and by generating agronomic recommendations derived from on-farm research, appears to be quite high and worthwhile investigating.

Very few farmers grow rapeseed. While it is a crop which might have some future in the high-potential areas, its introduction has yet to be attempted on a wide scale. The main limitation to rapeseed production is its requirement for relatively good ecological conditions very similar to other crops considered much more important by the farmers, such as maize and wheat.

Groundnuts are being grown in several areas of the country but not for oil production. They are either consumed at home or sold for confectionery use and for processing into peanut butter. Internationally, groundnut oil achieves a premium price due to its high quality and identifiable taste which justify its production even when the yields are relatively low. Since that specialized taste for groundnut oil is not widely developed in Kenya, its market potential is restricted to the Asian community which could be willing to pay a higher price for it because of their familiarity with its taste.

Coconut trees are grown all over the coast. They are a source of juice, food and income for the farmers without having to spend much time and effort on their cultivation and care. The common practice is to wait until the nuts are mature to harvest them for use at home or for selling as whole nuts or copra. Most of the trees are old, and farmers do not have replacement programs. New trees are planted only when the old ones die. The majority of the farmers obtain their seedlings from the Ministry of Agriculture; few farmers have their own nurseries. Little or no fertilizer is used, and pests are not controlled. Several other annual and perennial crops are associated with coconuts. Few farmers keep coconuts in pure stands, and when they do the grass which grows below the trees is used for livestock keeping.

The marketing of nuts and copra is not well organized. Buyers go around at irregular intervals purchasing directly from the producers and paying on the spot. They resell the products to the city markets or to the industry. The producers complain that the traders' margins are too high. One cooperative buys copra to produce oil but its payments are often delayed. While farmers consider coconuts a good source of income, they do little to increase the production of existing trees or to increase the area planted. They blame the markets for lack of incentives.

Objective 3

To describe the technological characteristics of each component, its use of the factors of production and its contribution to value added.

To describe the technological characteristics of the industries -- fats and oils, animal feeds, soaps and detergents -- industrial engineers who have specialized in this type of plants are required. No professionals were included in the team to fill these positions; thus the required data were not gathered. The information collected through the questionnaires is insufficient for a detailed description of the existing machinery, use of factors of production, etc. The most significant result obtained, based on the information gathered, is that the capacity of utilization of the plants is low -- perhaps below 50%.

One area which was not originally included in the objectives of the study, but which is becoming very important in the situation in which the system operates at present, is the role of private promoters of oilseed cultivation.

In the seventies, Elianto, the owners of one of the first solvent-extraction plants established in the country, began the private promotion of oilseeds production by encouraging the cultivation of sunflower as an oil crop. After a few years the promotional effort was discontinued because the poor yields and the low oil content obtained did not make the cultivation and processing of sunflower a viable enterprise, either for farmers or for the industrialist. The solvent-extraction plant was then reoriented to the processing of maize germ to obtain maize oil.

East African Industries (EAI), the biggest refiner and packer of vegetable fats and manufacturer of soaps in the country (owned by a Food Processing Multinational and the Kenyan Government), also started the promotion of sunflower in 1981 under a newly created Oil Crop Division. The following year a contract-farming model was adopted based on the satisfactory experience of other local companies dealing with tobacco and barley.

In 1985 EAI, in association with the International Finance Corporation and the Commonwealth Development Croporation, expanded its Oil Crop Division into a subsidiary company, Oil Crop Development Ltd., for the specific purpose of promoting sunflower and other oilseeds. This decision resulted from studies carried out at a time when the international prices of oils and fats reached all-time highs. After some initial difficulties over how, where and on whom to concentrate the promotion efforts, the new company successfully encouraged the growing of sunflower, and to a limited extent rapeseed, among small farmers by providing seeds and technical assistance.

However, by the time those some results were beginning to be seen in 1986 the international prices of oils and fats had collapsed to less than half of their previous highest levels, making the importation of palm oil a bargain. Since the company guaranteed to buy sunflower from the farmers at pre-established prices and had to sell the crude oil to the parent company at a price based on the world market price, the promoting company incurred severe losses. In order to reduce these losses, it cut the nominal price offered to the farmers for the 1987 season by 30%, reduced personnel and operational costs and, as a consequence, curtailed promotion and supervisory activities. The parent company also persuaded Government not to reduce the price to consumers of the final products by as much as the international prices had gone down. The extra income generated by the higher processing margins would be used to continue with the promotional activities and to cover the losses already incurred by the subsidiary company in charge of them. These combined measures resulted in an improvement of the subsidiary company's gross profits which were used to pay creditors and thus reducing financial costs.

While the relatively low prices paid to farmers had an immediate positive effect on the company -- although this was still much lower than expected, as explained below -- by improving its financial position, they had, however, two compounded long-term negative effects.

One was caused by some oil processors who (deprived of their normal supply of cottonseed due to reduction in the area of cotton cultivated) were prepared to buy sunflower seed from the promoted farmers at a higher price than that offered by the promoting company. In this way they were able to keep their plants going by buying seed which the promoters considered theirs -- and an activity described as "poaching" came into being.

The other effect is that many farmers decided not to grow sunflower any more because of the reduction in the economic rent generated by the crop, which was already considered to be low.

The first negative effect mostly affects the company itself because it will not be able to buy enough seed to cover its cost of operations and promotion, and to utilize the crushing capacity put at their disposal by the contracted crushers.

The second negative effect could have much longer lasting damaging consequences, not only for the company itself but also for other production-support efforts. If a substantial number of farmers cease to produce a commodity, which has been vigorously encouraged, because after two or three seasons the price paid for it is uneconomical, the likelihood of those farmers later returning to the production of the same crop or accepting similar promotion efforts is very small. In other words, the transference of the risks of international price variability to the small farmers results in long-lasting negative effects which could nullify any present and future promotional efforts.

To some extent what has been said for sunflower is also true for rapeseed, a crop which has recently been privately promoted by the same company. but in the case of rapeseed the level of promotion and acceptance has been much smaller and only comparatively few farmers are involved in its cultivation.

The Unga Group of Companies (the biggest holding group involved in the production of human foods and animal feeds in the country, and which bought out Elianto some years ago) established a new subsidiary company called Ufuta. Ufuta started the promotion of simsim cultivation for edible-oil production. Its operations are carried out through the co-operative movement and the extension service of the Ministry of Agriculture. The product has been on the market for the last two years and it appears to be well accepted. The advantage of simsim over other oilseed crops is that it has been grown locally for many years and it is adapted to local conditions.

The promoters of simsim are enthusiastic about the results achieved so far and are planning to continue their promotional efforts.

Objective 4

To find out the present level of consumption and estimate the future demand of vegetable oils, fats and, protein cake as derived from dairy, poultry and pig industries.

An estimation of the level of consumption of the different products generated by the system was difficult because up-to-date information was not available. The latest complete analysis of the food-consumption pattern of various income groups in rural and urban Kenya which was available to the study group was done by Frohberg and Shah in 1980 and was based on information collected in the rural survey of 1974/75 and the urban survey of 1977. The average level of consumption of vegetable and animal oils and fats -- excluding butter -- was estimated for the population as a whole at 1.32 kg per capita per year. The highest levels were recorded among high-income groups in Nairobi with a consumption of 4.55 kg per capita per year.

If the average national value is multiplied by the country's population estimate for 1987 of 22 million inhabitants, the total consumption of vegetable and animal oil and fats for that year should have been 29,000 MT. However, the importation of palm oil alone reached 124.000 MT. It is obvious, therefore, that the consumption values obtained more than ten years ago no longer apply under present levels of development, urbanization and income.

The same conclusion applies to the consumption of all other products related to the vegetable oil/protein system because the latest surveys are similarly out of date. Without reliable information on present levels of consumption it is not possible to generate adequate predictions of consumption for the future. Nevertheless, it is possible to postulate that the level of consumption of most of the consumer products generated by the oil/protein system (i.e. oils and fats, soaps, eggs, poultry and pork meat, dairy products, etc.) will grow at least as fast as the population due to the positive demand effects caused by the rise in per capita income and urbanization.
Another approach which could have been followed was to take the estimates of production and divide them by the population. Here again the problem of unreliable information was encountered. The published data on production of ghee and fats and cooking oil is about half that of the estimates derived from raw-material availability and processing.

The last time livestock census carried out was in 1969. From then on, yearly estimates of the livestock population have been made based on the previous year's numbers, incomplete district data and assessment of probable changes due to weather conditions. The latest published information is conflicting and in disagreement with other variables related to the sector. Thus to use this information without verification to derive the demand for animal feeds by the dairy, poultry and pig industries is not recommended.

Nevertheless, this is an important objective which cannot be neglected if we are to understand the system and, in turn, formulate more appropriate policy interventions. What is required is the development of an effective and efficient data reliability and validation effort to ensure that the information used to estimate present values and predict future ones is an accurate reflection of reality.

Objective 5

To define the policy instruments which influence the oil-protein system, determine their setting mechanisms and estimate their quantitative impact.

Price-control policies affect various products of the oil/protein system. They can be categorized into three main groups:

1. Price-controlled products are those for which the Government fixes prices through notices in the official Kenya Gazette. All vegetable fats and oils and liquid milk fall into this category (soaps and detergent were decontrolled during 1988). The Price Controller's Office reviews these prices periodically in consultation with the ministries in the sector and the Ministry of Finance.

2. Generally, controlled products are those for which the industrialists, on an individual basis, present price proposals based on their costs and benefits analysis for consideration by the Price Controller. The Controller, in consultation with the relevant ministries, agrees, modifies or rejects the proposal. Animal feeds fall into this category. While the sale price of feeds is controlled, the raw materials have to be purchased in the open market. This partial control of prices of one of the components of VOPS leads to specific problems in the quality and availability of animal feeds.

3. Finally, there are the products over which the Government does not exercise any price control but whose prices are set by existing supply and demand. The commodities of the oil/protein system which are not subject to price control are oilseeds, protein cakes, day-old chicks, pigs and dairy animals, poultry, pork and dairy products (with the exception of liquid milk), and the recently decontrolled soaps and detergents.

Two commodities, maize and cotton, are substantially different from the rest. Both generate oil as by-products and are managed by marketing boards.

The National Cereals and Produce Board (NCPB) handles the maize that the millers use for the production of sifted maizemeal, bran and germ. NCPB buys the maize from the farmers at an established price and sells it to the millers, also at fixed prices. The millers have to sell the sifted maizemeal at a gazetted price but are free to set the price at which they sell the maize bran to the animal-feed compounders and the maize germ to the oil extractors.

The Cotton Lint and Seed Marketing Board (CLSMB) buys cotton seed through agents at an established price and delivers it to the ginneries for custom ginning at a processing fee. The cottonseed obtained is sold through tendering to the oil extractors. Since recently the amount of cotton available has not been enough to satisfy the requirements of the crushers, the amount at the CLSMB's disposal is allocated to the various processors on a quota basis.

The main difference between the handling of the maize and cotton by-products used for the extraction of oil is that while maize germ is sold by the millers to the processors under a commercial agreement between private business, cottonseed is sold at fixed prices and allocated by quotas to the processors.

Another important set of policies which influences the oil/protein system is the tariff duties being levied and the sales taxes imposed on various raw and intermediate products. While the sales taxes are charged regardless of the origin of the products, the tariff duty varies depending on whether the imported product comes from the Preferential Trade Area (PTA) or from outside it.

All oilseeds have a tariff duty of 20% if imported from the PTA, and most of them have a tariff duty of 35% if imported from outside the PTA. Only sunflower seed and rapeseed are free from tariff duty if imported from outside the PTA.
Most crude and refined oils have a tariff duty of 28% if imported from within the PTA area and 35% from outside it (Olive oil is levied at 35% and 45%, respectively). Crude oils are exempted from sales taxes, but refined ones have to pay 17%. The only two refined oils which are exempted from sales taxes are palm and palm kernel oil.

Tallow has a tariff duty of 14% if imported from within the PTA area and 30% from outside it. This animal fat, mainly used in soap making, is exempted from sales tax.

In the last few years, the quantities imported of the various products have been substantially affected by the remission of the tariff duty on palm oil. Importers of crude palm oil have enjoyed a remission of 100% of the tariff duty since 1984. Part of the tariff duty (72%) was remitted to importers of refined palm oil starting in July 1986. The percentage remission was changed to 57% in July 1987 and finally increased to 100% in July 1988. In other words, crude and refined palm oil do not pay any tariff duty or sales tax at present.

The outcome of combining the exemption of sales tax on refined palm oil and a remission of its tariff duty has been a reduction in the amount of tallow imported from 15,500 MT to 5,200 MT and of crude palm oil from 95,100 MT to 38,700 MT between 1986 and 1987. During the same period the importation of refined palm oil increased from 1,000 MT to 85,800 MT, resulting in a reversal of the original intention to protect the local production of oils and fats.

There are other policies which affect the vegetable oil/protein system, e.g. agricultural credit and exchange rates, but since they are not directly oriented to the sector, and since it is impossible to modify them unilaterally, their impact is considered as given.

Objective 6

To identify, assess and assign priorities to specific areas of research leading to the removal of constraints to local oilseed production and processing into edible oils and protein cakes.

The work done by the seven study groups has thrown light on the structure of the system, its linkages and its potential for development. There are still a few unknown and several partially known factors that limit a complete understanding of the full system and its reactions. Nevertheless, policy formulation and implementation must continue, based on information which is presently available. Key areas of intervention which have been identified are presented below.

Research is needed to tackle the most critical problems for which there is no answer at the present time, as a necessary complementary function to policy. The research results will steer the decision-making process in the medium and long run to the final removal of constraints to the achievement of the national objectives set up by Government. Below is a description of suggested research intervention points for the elimination of obstacles to domestic production of oil and fats.

The lack of locally produced raw materials is the major constraint confronting the industry.

Two of the main sources of raw materials -- cottonseed and maize germ -- are by-products of other industries. The oil content of those by-products is relatively low, which limits their potential for oil-extraction purposes alone.

The production of seed cotton has decreased significantly in the past few years due to important reductions in the area seeded as farmers feel discouraged by the delays in payments by the CLSMB. The decline in seed cotton production has a magnified effect on the availability of cottonseed for oil expelling because of the already mentioned need to retain sufficient planting material.

The crushing plants have not received sufficient processing material in the last few years and are working substantially below capacity. Due to their dependence on the CLSMB for supplies of raw material, they have not developed purchasing mechanisms to obtain other oilseeds from the farmers. Recently, out of necessity, some processors started to buy sunflower seed directly or through agents, leading to a negative reaction from the promoters of the crop who had expected to have most of the seed for their own use.

The 1988 decision to restructure the cotton industry signals Government's intention to return the production of cotton seed to its previous levels. This could be achieved if farmers are guaranteed fair prices and prompt payments. Even if this is accomplished, however, the availability of cottonseed for oil production will be much less than the amount required to satisfy the oils and fats market.

It is unlikely that a significant increase of maize germ quantities for oil production, i.e. substantially greater than the rate of population growth, will take place. It can be expected that increases in maize milling will closely follow, but not exceed the increase in population.

In other words, while it can be expected that action will be taken to return the amount of cottonseed oil extracted to previous levels, and for maize oil to continue to play an important role in the upper-income liquid oil market, neither of these crops individually or combined can make a sizable additional contribution to solving the problem of lack of raw materials for the oil/protein system.

The oilseeds which could make a vital difference in the short term are those annual crops which could be seeded in previously uncultivated land or associated with other existing crops. The ones that appear to be most promising in the immediate future are sunflower, simsim and rapeseed. Sunflower and simsim are widely known, and rapeseed is slowly catching on. They are the crops most cultivated at present, and the existing processing industry is interested in them. The biggest limitation to their expansion is the producers' concern that insufficient income is being generated by the cultivation of these crops. Many farmers accepted the promotional efforts of the last few years, but more recently (and especially after the reduction in prices), some of them have stopped production.

Given the low level of inputs presently used by farmers, the question of income and economic rent basically depends on two factors: prices and yields.

Prices

The Government of Kenya is well aware of the need to maintain incentives for producers by periodically reviewing controlled prices. Moreover, it has been following a consistent policy of decontrol, allowing market forces to play without intervention.

During 1988 the Government decontrolled the price of soaps and detergents; in June it increased the price of margarine by 17% and, as recently as November 1988, it increased the prices of all vegetable oils and fats (including margarine) by 10% resulting in a total increase for the year, of 29% for margarine and 10% for the other products. Those increases were made at ex-factory, wholesale and consumer levels. The average margins for wholesalers remained the same and those for the retailers were slightly increased.

It is still too early to assess the effects of these price increases in this attempt to maintain the profitability of the refining and packing industries in the face of higher prices for imported palm oil. Two questions become relevant. Will the increase in prices to consumers be translated into higher prices to local producers so as to generate the incentives which will induce them to cultivate oilseeds? And, if so, can the system sustain the incentives in order to achieve the desired national goals, including self sufficiency?

Recent experience shows that the interest in promotional efforts was provoked by the high international prices existing in the early eighties. As soon as the international prices went down (a reduction that was not wholly passed on to the consumers), the situation triggered a reduction of around 30% in the prices to farmers -- an action which, in itself, i.e. regardless of its effect on income, discouraged producers.

In other words, promotional activities which required a sustained long-term endeavour, were allowed to be negatively influenced by the highly volatile international market. That is what happens whenever the world prices are low and the refining and packing enterprises make more profit by importing oils and fats from overseas than by buying the locally produced oilseeds, even at substantially reduced prices.

It also took place when the Government -- reacting to the rise in international prices of palm oil -- firstly, reduced or nullified tariff duties by remissions and exempted selected products from sales tax, and secondly, increased consumer prices in order to maintain the economic rent of the packing enterprises and to avoid scarcity of consumer products on the market.

The present implicit message to the industrialists is that duties and taxes will be reduced or eliminated and consumer prices rise in order to secure supplies, with the inverse (higher duties and taxes and consumer-price reductions when world markets go down) not necessarily happening in the same proportion. Under these circumstances, the industry is assured that the continued use of imported materials protects its minimum economic rent during periods of price increases and allows for extra benefits during times of international price reductions.

To avoid the present discontinuity in effort that could culminate in the farmers' complete disregard for oilseed crops, prices paid to them have to be kept remunerative and dependable by being isolated from the erratic fluctuations of the international markets.

The same principle of continuity applies to the promotional activities of the vegetable oil and fats industry. For the industry to be interested in fostering the production of domestic raw materials and committed to their constant utilization, it must be induced to buy locally. This can be achieved by making domestic oilseeds competitive and eliminating the potential for benefit from the fluctuations of the international market.

There are several levy and quota mechanisms which can deal with these problems. One of these mechanisms is the prop price variable levy which has been successfully used by several countries for the promotion of local production and the reduction of imports.
This adjustable duty is applied to products which are imported at values below the prices established by Government to ensure that all importers pay at least the same prop price for the imported goods. This levy is sometimes combined with a percent duty which applies when international prices are higher than the prop price. The fiscal revenues generated by these levies are commonly used for promotional efforts of local production. In the case of oilseeds they could, for instance, be used to provide loans to industrialists interested in developing their own promotional efforts.

Additional incentives for the utilization of local raw material could be provided by remitting a portion of the duties paid to those industrialists who reduce the quantity of oil and fats imported from year to year. Discouragement could be effected by proportionally increasing the levies for those importers who escalate the use of foreign raw materials.

Another possible course of action, already used by Government with dairy products, is to maintain the control of prices to consumers on a few products only -- in this case those fats and oils which are imported -- and to decontrol the consumer price of those which are produced locally.

These policy measures, separately or in combination, should aim at stabilizing the price of foreign oils and fats at a reasonable level and making their importation consistently more expensive for the industrialists. It is expected that in this way they will be persuaded to utilize local raw materials which they will promote by paying higher prices to local oilseed producers.

Concerted action to try to generate incentives for farmers to grow more oilseeds, and for the industry to promote and use them through the long-term stabilization of prices, will require a rise in prices throughout the system, including those to consumers. Higher consumer prices will result in a decrease in demand, especially by those less-privileged groups (with lower cash incomes) in the rural areas.

To deal with this undesirable consequence a two-tier approach should be taken. It will include the existing commercial extraction, refining and packing plants to satisfy the higher-income -- mostly urban -- markets and the rural processing of oilseed to provide for the low-income rural market, as discussed below under the heading of rural processing.

The issue of farmers' incomes cannot be looked at only through the keyhole of prices. Yields are equally important in the determination of income.

Yields

The problem of low yields is very relevant in the four most popularly grown oilseeds (sunflower, simsim, coconut and rapeseed) in the country.

Sunflower: In spite of the fact that sunflower has been grown for several years in Kenya, its potential for high-yield production under local agro-ecological and socio-economic conditions is still in doubt. The yields of sunflower being obtained by Kenyan farmers are well below international levels, even in those countries where fertilizer is little used.

The restrictions imposed by the equatorial location of the country, the bimodal rainfall pattern, the abundance of birds, the opportunity for cross-pollination with low-oil-content white sunflower which is being grown for bird-seed, the lack of pollinating insects at the appropriate time, and the fact that it is grown as a secondary crop, could all act as limiting factors. Little systematic research has been carried out to identify and resolve the problem which, as happens in most such cases, is probably a result of a combination of climatic, genetic and agronomic factors.

This is the reason why research efforts should be concentrated on identifying those limitations and developing mechanisms for dealing with them during the next few years. If, after a reasonable period of time, there are still serious problems of adaptation which cannot be resolved in the foreseeable future, then the resources should be used to explore other more promising possibilities. In other words, sunflower has yet to prove itself: if it does not do so after a certain period of time, the human and financial resources dedicated to research on the crop should be turned to other crops.

Simsim (sesame): Simsim is an indigenous East African crop with a high oil content. The oil is easy to extract and refine and is of good quality due to the high content of saturated fatty acids.

The crop has been grown in Kenya for many years without any special promotional or direct extension efforts. It was only recently that Ufuta started fostering its production by purchasing the seeds at a fixed price. The potential for the crop seems quite promising because of its adaptation and acceptability by the farmers. Research is needed, however, to fully develop the crop's capabilities, especially by identifying the most appropriate agronomic practices for better yields and the classification and selection of those lines which are best adapted to local conditions. Of special concern is the shattering at once of the capsules at maturation which significantly reduces the quantity harvested.

Coconut: The area dedicated to coconut plantations at the coast seems to be stagnant. Being a perennial crop, coconuts are a long-term investment. The promotional effort needed to expand the area planted must include some credit component to finance the establishment of the crop, including a grace period to cover the waiting time until it produces enough to start making payments on interest and principal.

There are good possibilities of improving the yields of plantations already in existence through proper care and management. A comprehensive extension effort should be made to disseminate agronomic practices successfully used in other developing countries.

Another area which requires extension efforts is the post-harvest treatment of the nuts. The quality of the copra being produced is poor, which affects its value because of the small amount of oil being obtained. This aspect is closely related to the marketing of the nuts and the copra which appears to be segmented, disorganized and inefficient.

Rapeseed: Rapeseed has been introduced in the last five years. It has the potential to become an important crop within the farmers' production system in the highlands. Its ecological requirements are very similar to other important crops in the area such as wheat, barley, etc. Thus, it will be difficult to justify its cultivation as a replacement for those crops. Instead, the prospects for rapeseed lie in becoming part of the rotation pattern covering periods when land would ordinarily be left fallow.

Research to identify the most suitable varieties under Kenyan conditions and the required agronomic practices to foster high yields is still to be carried out. While rapeseed has potential, the research efforts devoted to it should not be at the same level as sunflower and simsim which have higher priority at the present time.

Rural Processing

The rural processing of oilseed at the farm or trading-centre level is a noble idea in Kenya which could have a significant impact in the production and consumption of oil bearing-crops.

Two types of machines are available which can serve the purpose. One is a hand-operated ram press which has been used to extract oil from sunflower for direct consumption and the other is an engine-driven low-capacity expeller which can also extract oil from this and other oilseeds and has a relatively higher daily output. Both machines produce protein cake as a by-product which can be used as a protein supplement for direct consumption by livestock.

The dissemination of these machines in the rural areas and their acceptance by the population could have a significant impact, not only in the production of oils but also on their consumption. By the adoption of ram presses and/or low-pressure expellers in the rural areas, oils are transformed from being a strictly commercial product -- which requires cash to purchase -- to home - or custom-processed commodities which require no cash to obtain. The rural processing of oilseeds could modify the whole patten of oil and fats utilization, and lead to improved nutrition by increasing energy intake through the consumption of locally produced vegetable oils.

The utilization of the by-product (protein cake) to supplement the rations of livestock, especially milking cows, could also have a positive effect on income and nutrition by making more milk available for local consumption and for processing.

The rural processing of oilseeds appears to have the potential to satisfy several Kenya Governmental objectives, e.g. rural industrialization, generation of rural income, creation of employment, improvement of nutrition and reduction of the foreign exchange burden.

Nevertheless, the introduction of unfamiliar processing technology at the rural level is a task which requires systematic and careful planning, programing, monitoring and evaluation. It cannot be done carelessly and without looking at the several components which the rural population will take into consideration before investing their scarce resources in an innovation.

Factors such as the identification and bulking of planting material, the varieties and/or hybrids of oilcrops which have good yields and are easy to process, home utilization by humans and animals of the oil and cake and the marketing of surpluses should all be taken into consideration. Issues such as quality, toxicity, filtration, storage, and shelf-life of the oil; the preparation and proper mixing of rations containing the cake and the other locally available feedstuffs for various species of animals; and types of ownership of the machines, cost and benefits of operating them, and labour requirements, must all be addressed. Attention to these factors will ensure that the rural population are offered machines that are reliable and will produce products which are safe to consume by themselves and their animals and which will improve their economic well-being.

If the introduction of the machines and the technology attached to them fails because the technology is worthless no damage is done. If, however, the technology has merit but its introduction fails because many of the factors which affect it are ignored or not properly dealt with for lack of understanding of the complexity of the adoption process, the cost to society is inadmissibly high.

Fats and Oils Industry

The main finding of the study group dealing with the fats and oils industry was the low level of utilization of the existing extraction plants, especially those using pressure methods to obtain oil from cottonseed and sunflower. Nevertheless, those plants seem to make some profits because, in spite of their low profit throughout, they still continue in operation.

An analysis of the present costs of production and the efficiency of the existing plants could throw light on how much the per-unit cost could be reduced by substantially increasing the capacity utilization of the plants and improving their efficiency.

From the study it was not possible to ascertain the accuracy of the plant-capacity values provided by the owners and used in the calculations. This was especially so when the machines are several years old, lack proper maintenance and often break down and remain unused for long periods due to the shortage of spare parts, as expressed by the owners themselves.

The issue of effective plant capacity is an important one because, if the Government decides to introduce policies leading to greater local cultivation of oilcrops, the industry should be ready to absorb and process that increased production of oilseeds. If the existing capacity is sufficient to handle the expected growth, no immediate problems will arise. But, if more capacity is required, the appropriate investment plans should be prepared well in advance to ensure that promotional efforts at the farmers' level are not frustrated by the industry's failure to generate the required crushing capacity.

Another industry which is becoming an important component of the system, and which should be properly analyzed, is the manufacturing of soaps and detergents. Initially, it was not considered part of this study because the main raw materials used in their processes have been tallow and coconut oil, which were not used for human consumption. That situation has changed in the last year due to the reduction in the importation of tallow and the equivalent increase in the importation of palm oil -- as a consequence of changes in the relative prices of both commodities -- and the installation of a processing plant able to refine coconut oil to the level required for human consumption.

Now, with tallow and vegetable oils competing as sources of cheap raw materials for soaps, and coconut oil being available for soap manufacturing as well as for human consumption, the soap and detergents component becomes an integral part of the system, and it should be dealt with as such.

Firms which now specialize only in refining, hydrogenating and packing of imported materials without having their own crushing capacity will have to change their modus operandi and establish direct commercial contacts with existing crushers or develop their own crushing capacities. The identification of the existing linkages and flows within the oils and fats industry becomes a necessary step to a better understanding of how it functions at present and how it will develop in the future if the Government decides to support and encourage the cultivation of oilcrops and the local production of fats and oils.

System Analysis and Incremental Approach

The findings of the different groups provide strong evidence for the need and importance of following a system strategy and an incremental approach to research, programing and implementation for a sectoral development program.

The relevance of the system strategy became evident when trying to analyze and link together the major components of the oil/protein system. Through this process, it was possible to identify some components which were not originally considered of significance but, if ignored, could jeopardize the understanding of the existing system and its future development.

Moreover, it helped to identify sets of related data published by or obtained from different sources which were contradictory or inconsistent, throwing doubt on any conclusion and/or recommendation based on either of the non-validated data sets.

The advantage of the incremental approach being followed is that the present results are not taken as being definitive but only as stepping stones for revision, development and refinement. The information already available can be corrected, improved, validated, added to and further analyzed so as to improve the knowledge of the system and the foundation on which decisions are based.

The combination of both approaches has been instrumental in allowing each one to demonstrate the importance of the other. The analysis of the system as a whole is germane in itself, but to what degree of disaggregation should it be described? It could take several years and a great deal of human and financial resources to identify all the components, their linkages, flows, utilization of factors of production, etc. before it is accepted as a complete model of the industry. On the other hand, the incremental approach could be justified on a component basis, the question being which components should be tackled first and to what level of detail should one component be analysed before considering another one for review?

It becomes apparent that by incrementally analyzing the system as a whole the deficiencies of each independent approach are resolved and the overall analysis grows to be of greater use to decision-makers in Government and the private sector. In this way, the generation of a policy and research agenda becomes a continuous and interlinked process by which adjustments can be made based on the permanent collection and analysis of information generated by the system as it reacts to research findings, policy modifications, market changes and the vagaries of the weather.

Generation of Research Capacity

Egerton came into being in 1939, 50 years ago. It became internationally recognized as an agricultural college producing well-trained diploma holders with practical experience. The institution was elevated to university status in 1987 and immediately thereafter its Division of Research and Extension was created. Among the Division's goals were:

- To harness, develop and expand the available technical and human resources of the University faculty in research and extension activities appropriate to Kenya's development;
- To create a structure and an operational system conducive to furthering effective research and outreach delivery programs; and
- To attract technical, financial and experienced human resources to the University to complement its own.

Egerton is a new university with a long tradition of students learning how to deal with real problems by working together with the farmers in their own fields. The goals set up for the Division of Research and Extension indicate that the same practical, problem-solving orientation will also guide its research and extension activities.

Several Egerton University faculty members participated in the various VOPS research grows, making very useful contributions. An incipient research capacity already exists but it requires additional development. Three areas of intervention have been identified: interaction with other researchers; research involvement; and further training.

Interaction with Other Researchers

At present, neither Egerton nor any other single Kenyan institution has sufficient professional staff with enough research experience to carry out investigations in all the areas which have been identified as requiring intervention. In other words, for research to take place with a systems approach professionals from universities, ministries and other institutions will need to join together in teams.

The participation of the more

seasoned researchers from various institutions should not be seen as a hindrance. Instead, it should be viewed as a way to get several other organizations involved in the research process and as a way to disseminate results and spread the knowledge being developed about the system and how it operates.

Research Involvement

Researchers from other institutions could make significant contributions, but they will not be able to participate on a full-time basis due to their other obligations. To achieve continuity in the research activities and to ensure involvement of young professionals who are already part of the Egerton University establishment, such professionals who have recently obtained their masters degrees could be hired or assigned to take part in the research activities on a full-time basis, thus building their capacity to carry out research in a problem-oriented project.

Further Training

A university interested in becoming a centre of academic excellence in problem-solving research has to pursue the objective of having most of its faculty members at the PhD level. This long-term objective has to be carefully and systematically pursued. Given the investment involved in doctoral studies the professionals allowed to continue their careers up to that level should be conscientiously selected. One important criterion is their interest and dedication to carrying out significant research. The opportunity to participate in research which could be given to the masters degree holders mentioned above could be a significant and meaningful way to evaluate and measure their capabilities to ensure that the development of human capital is properly undertaken.

Integration of Efforts and Institutional Building

The decision to carry out a comprehensive study of the industry by seven groups of professionals from ministries, parastatals, universities and the private sector

co-ordinated by Egerton university has paid off handsomely. The interaction within groups, and especially between groups, has allowed everyone involved to have a better understanding of the sector as a whole and has created awareness of the problems involved in each components.

It has also been useful for the members of the teams to become cognizant of the weaknesses of the data they have been using within each component, which in many cases is inconsistent with the information provided by other components.

Finally, it has provided the Division of Research and Extension at Egerton University the opportunity to begin to acquire experience in the handling of the finances of a project in which individuals from different organizations participate.

In the future, as policy interventions are applied and research is carried out, the need for an integrated effort becomes event more important to ensure that proper co-ordinated planning, programing, monitoring and evaluation of activities takes place.

Egerton University will have to develop a full research management capacity from the technical and financial points of view to guarantee that activities are properly organized and have the adequate financial backing. The intervention in this area is not only important for this project, it is also crucial for the success of the whole research and extension endeavour of the institution.

Objective 7

To prepare a project proposal for the subsequent phase which will include those areas of research with the highest national priority and expected pay-off for the Kenyan economy. The proposal is to be presented to donors for financing.

To clearly segregate the functions of reporting from those of proposing, the proposal for a next phase is presented as a separate document.

BRASSICA SUB-NETWORK
ACHIEVEMENTS AND ACTIVITIES, 1987-88

Hiruy Belayneh

The developing countries are passing through a critical phase of edible oil shortage. It has been realized that through better coordination and cooperation among the developing countries and strengthening their research program, the major problems which limit the productivity of oilseeds can be overcome.

Under the umbrella of the Oil Crops Network, IDRC has helped the establishment of four oil crops sub-networks (Brassica, sesame, sunflower and other oil crops) to bring a number of scientists from East African and South Asian countries at the respective platforms and provide forum to address their common issues. In the different circumstances of both Africa and Asia, it was first necessary to identify, define and rank the importance of the constraints so that member countries may collaborate with each other in exchange of material, information and scientists and provide opportunity for training.

First Brassica Sub-Network Meeting

In the past decade oilseed Brassica has undergone the most rapid expansion in area and production. Until recently much of the research on the crop has been concentrated on selected problems of interest to single scientific disciplines. It was the research on breeding and crop protection of oilseed Brassica that first led to the conviction that there should be close collaboration among the African and Asian scientists.

In May 1987, scientists from Brassica improvement programs in Ethiopia, India, Canada, Pakistan, Egypt, Kenya, Sweden and P.R. China met in Uppsala, Sweden to discuss the research needs of oilseed Brassica and to formulate a Brassica sub-network under the umbrella of the Oilcrops Network of IDRC. During the discussion germplasm exchange, information exchange and training were identified to be potential fruitful areas for collaboration.

Achievements After 1st Meeting

Seed registry

The regional activity was started with the preparation of the seed registry. Breeders from some of the member countries made available the update list of varieties that have been released so far for future references. This compiled list will be distributed to member countries.

Germplasm Exchange

Sixty-three oilseed Brassica varieties were collected from P.R. China, Ethiopia, India, Nepal and Sweden through the Oil crops Network Project and distributed back to those who contributed to the nursery.

Training

National programs were able to contact each other to organize specialized training where the expertees are available. One Ethiopian Field Assistant got his training at G.B. Pant University, Pantnagar on oilseed Brassica improvement. A technician from Nepal is now being trained at the same university.

Information Exchange

The member countries were sharing information through Oil Crops

Newsletter, Cruciferea Newsletter and CGIRC Bulletin. The 1st and 2nd Brassica sub-network workshops were also useful forum for information exchange. The first workshop was focussing on status and strategies of oilseed Brassica research while the theme of the second meeting was on technology transfer.

A monograph that reviews and brings together the known information on aphid screening and breeding methods has been prepared by Drs. Basudeo Singh and D.R.C. Bakhetia and distributed to member countries. It has been compiled for Brassica researchers for their consultation and guidance.

The Brassica researchers from Ethiopia and Egypt were able to share the information on Orobache situation in Nepal. The study was thorough and the write up was excellent.

Second Brassica Sub-Network Meeting

The second Brassica sub-network meeting was held at Pantnagar, India, 4-6 January 1989. This workshop was organized jointly by IDRC and G.B. Pant University of Agriculture and Technology. There were over 30 participants from 8 countries at the workshop. The basic theme the meeting addressed was technology transfer.

The presentations started after the welcome address by Dr. S.C. Modgal, Director of research, Pantnagar; opening address by Dr. Mahatim Singh, Vice-chancellor and response by Dr. Nicolas Mateo, IDRC Regional Program Officer, New Delhi. Details of the opening session and the presentations will appear in the proceedings. My paper was on "Role of High-yielding Varieties and Production Technique on Oilseed Brassica Performance in the Central, South-eastern and North-western Zones of Ethiopia". As a chairman of the Brassica sub-network committee, I also presented a status report covering 18 months period.

Recommendations of the Second Meeting, 1989

The major recommendations of the Brassica Sub-network for the coming 18 months follows:

a) Coordination

To make sure that the agreed collaboration work is carried out, the idea of five core committee members was accepted. Since Ethiopia and India are already represented as chairman and co-chairman, respectively, the nomination was opened to the other member countries and one participant from each of P.R. China, Nepal, and Egypt were chosen. Only the chairman and co-chairman will serve as steering committee members of the oilseed network. It was also agreed that wherever a member country is not represented in the committee, the respective government authorities will be approached to nominate one scientist actively involved in the development and research of oilseed Brassica as a contact person.

b) Exchange of material

Specific nurseries are not recommended at this stage. Such nurseries would be constituted once the program goes. The present material exchange system will be a kind of collective nursery where-by each member will send 500 gm seed of released varieties and/or single plant selections to the network advisor. Those who contribute get the nursery. Government regulations and quarantine requirements ought to be fulfilled.

For member countries who have mutual interest on specific problems such as screening for resistance to Orbanche, blackleg, etc. a cross-boarder nursery exchange for advised depending on quarantine requirements. Bilateral issues among centers on CMS line exchange for hybrid production was left for the respective member countries (P.R.China, India and Canada).

As a follow up of the review work on screening and breeding techniques for aphid resistance, a screening program will be started in India with known material which have mild resistance. Sub-network members can be provided on request with best performing materials depending on the screening result.

c) Mutually Agreed Workplan for Common Problems

It was agreed that a review of the relevant literature be undertaken on Alternaria and drought. The reviewers will be Drs. Arvind Kumar and Basudeo Singh for drought and Dr. S.J. Kolte and a breeder (?) for Alternaria. Member countries are to supply relevant informations about the above topics to the reviewers in two months time so that the first draft can be completed in six months time.

Ethiopia is invited to prepare a review on "Orobanche situation in Ethiopia". A similar work was handled in Nepal last year.

Since there are too few well-trained and experienced scientists and technologies in various fields, the idea of bilateral cooperation (scientists support) was encouraged depending on the expertise and experience in a particular field.

d) Training

Pantnagar offered to provide a one-month training on Oilseed Brassica breeding and agronomy. This training which is to be organized for B.Sc. level and above will be held in December 1989. There will be 22 participants from 10 countries.

Member countries were encouraged to take advantage of the quality training which may be undertaken in China in April 1990.

e) Practical Field Bulletins

The idea of preparing a guide to identify diseases and pests of oilseed Brassica was welcomed. Two known Indian scientists (Drs. S.J. Kolte and G.C. Sachan) will prepare the field bulletins.

f) Meeting

P.R. China will be hosting the 3rd Brassica Sub-network meeting in April 1990.

Field Visit

On January 6, the workshop participants visited the oilseed Brassica research sites and farmers' fields. The first stop was at the disease nurseries where screening of Brassica against different diseases (Alternaria blight, downy mildew and white rust), and chemical control of the diseases are being carried out. There was a lengthy discussion on the relation between leaf pigmentation and Alternaria incidence. It was felt that the plants with purplish colored leaves are probably resistant to the disease since disease symptoms are not appearing. Such characters can be exploited for breeding purpose. The entomology work was concentrating on the mustard sawfly and aphids. The investigations were on assessment of yield losses, population dynamics, chemical control and screening of germplasm. A field naturally infested with sawfly was shown to the delegates. The participants were then led through the agronomy and breeding trials. The agronomy program is geared more towards maximizing production and working out the economic advantage of intercropping with various combination. The other management practice studies included fertilizer trials, supplementary irrigation study and the study on the efficiency of bullock-drawn seed drill. Dr. Basudeo Singh has carried out extensive hybridization programs on toria, yellow sarson, Indian mustard, etc.

Late afternoon, we went out to look at three farmers' fields and one field managed by the army. Best performance of Toria (*B. campestris*) has been realized because of the improved technology. The three farmers also followed the package which the researchers has recommended and are expecting yields between 15-20 q/ha.

On the way back to the university, the delegates paid a quick visit to Pantnagar Seed Processing Plant. The owners of this plant are the Indian Government, farmers and cooperatives. The company is responsible for certified seed production and marketing. For that, the foundation seeds are distributed to farmers who multiply and sell back to the company as certified seed. The collected seed passes through several processes for the purpose of adjusting the moisture, grading and treating before the marketing of the certified seeds. It was interesting to me to note that the group putting the certificate on each bag are from a different organization and the checking is done at four levels (field, before processing, at time of processing and before bagging). The seed company provides seed for Uttar Pradesh State and Bangladesh.

THE PRESENT SITUATION AND MAIN ACHIEVEMENTS OF SESAME PRODUCTION IN EAST AFRICA

Mohamed El-Hassan Ahmed

In Africa sesame is grown in about twenty countries with the main producers being the Sudan, Nigeria, Uganda, Ethiopia, Somalia, Tanzania and Kenya.

The cultural practices in the East African countries are more or less similar. The crop is mostly grown under rainfed conditions as a marginal crop on poor and marginal lands with poor management that result in low yields ranging from 80 to 500 kg/ha.

Great efforts were made towards sesame improvement in most of the countries considered but the situation with respect to its production - when the first breeding program was initiated - looks similar to the present situation. The total production or yields per unit area are low and stagnant with marked decrease compared to that reported at the research stations (1). Also a wide gap between the reported research station yield (2238 kg/ha) and the farmers' yields (80-400 kg/ha) was reported in Kenya (9).

This yield gap between the research stations' and the farmers' fields, in most of the East African countries, could be attributed to the lack of proper extension services since the crop is still traditionally treated as a minor and a marginal crop. The farmers fail to carry out the cultural operations properly and on time. The varieties, in the ordinary sense of the word, do not exist in the farmers' fields, but are mixtures of many types with poor quality and the farmers know nothing about the improved varieties or recommended cultural practices.

As shown by the production trends where a wide range (80-2,000 kg/ha) was reported and by the results of the experiments enhanced by the vast cultivable areas in the East African countries, it is apparent that sesame has a high potential for development in this continent. The shortage of financial and human resources, the difficulty of mechanical harvesting and lack of political will, resulted in little attention being paid to research on this crop. It is high time that national, regional and international efforts be directed to the improvement of this neglected crop.

Major Problems of Sesame Production in East Africa

The major problems of sesame production in East Africa are briefly discussed hereunder:

a) Seed quality

Sesame is generally grown by small holders who save their own seeds for sowing from the harvest of the previous season. Such seeds are usually a mixture of strains and of low purity, viability and germination percentage. Higher seed rates are usually used without thinning in most of the cases. Seed dressing to reduce pre-emergence losses, is usually not used.

In most of the countries under consideration, there is no agency for multiplication and distribution of high-quality seeds.

b) Cultural practices

Sesame requires a well levelled, fine seed bed but very little attention is given to its proper preparation in many countries.

In the East African countries, sesame is grown by manual labour except in the mechanized farming system in the Sudan. Pre-sowing operations are limited in many countries to breaking the land with hand hoe before the rains. Another method of preparing a clean seed bed is by burning the accumulated 2-4 years old dry grass after the onset of the rains known in the Sudan as "a harig cultivation".

With very few exceptions, sowing date depends on the onset of the rain which fluctuates and hence farmers often miss the optimum sowing date and fail to carry out weeding and thinning efficiently.

No fertilizer application or proper crop rotation is practiced in any of the countries under consideration.

c) Varieties

Most of the countries under consideration, grow land races, which are well adapted to their local conditions but have low yield potential and each is generally a mixture of strains (12). However, although the best strains were recommended, they cover only 13% of the Sudan's sesame area.

d) Harvesting

Harvesting is still a manual operation in these regions. It is the most difficult and labour consuming operation in sesame production which is estimated to absorb 60-70% of the total cost of production in the Sudan. Since it has to be carried out within about two weeks after physiological maturity, it leads to high labour demands within a very short period and consequently higher wages. In the Sudan the seed loss as a result of delay in harvesting may reach 30-100%.

e) Pests and diseases

In the seedling stages, the sesame plant is very delicate being readily damaged by drought, mechanical action of heavy storms, water logging on clay soils, ants, rats and grasshoppers. Also sesame may be attacked by many insects at various stages. As many as 30 insect species were recorded on sesame but there is a considerable difference in their relative economic importance from season to season or from country to country or even from region to region in the same country. The most important insect pests are: Flea beetles, Web worm (*Antigastra catalaunalis*), Sesame seed bug (*Aphanus sordidus*). This may cause substantial damage by sucking the maturing seed in the field prior to harvest, when stocked and even on the threshing floor.

Although many diseases such as phyllody, leaf curl, leaf spot, root rot, stem rot, and bacterial blight were observed in sesame fields, bacterial leaf spot caused by *Xanthomonas sesami* is still the most serious potential disease that threatens sesame production in most of the African countries.

f) Trained manpower

The most important factors responsible for low yield and production in the developing countries are lack of agricultural inputs, applied research and extension services (13).

Main Achievements of Sesame Research in East Africa

1. Genetic resources of sesame in Africa

Sesame can be found growing in tropical savanna, dry tropics, humid and dry subtropics (7).

Collection carried out in the tropical savanna and dry tropical areas of Africa in the Sudan, Somalia, Ethiopia, Uganda, Tanzania and Nigeria showed that the African local sesame types are vigorous, well branched, with one pod per axil and four locular pods with varying seed colours "white, redish, brown to black seeds". Uneven maturity and shattering of seeds are common in these African types. Beside these, wild species like *S. angustifolium*, *S.radiatum* and *S.alatum* are collected and used in the sesame breeding program in the Sudan.

2. Seed purification

It was noticed that the sesame seed produced by the peasant is a mixture of many colors. It reduces the selling value. Thus systematic purification for seed color of the land varieties by single plant selection was initiated in the Sudan. The separation not only ensures the purity of seed color but also raises the yield of the variety by eliminating the low yielding elements in the mixture (12). Ninty nine strains that bred true to seed coat color but differ in a number of agronomic characters were developed and some varieties with good potentials started to emerge from the mixed lots.

This work resulted in the isolation of four major groups based on seed color:

1) Ziraa. white seed A/1, A/2 and A/3
2) Hurria. brown seed A/4. A/5 and A/6
3) Tozi. grey seed A/7, A/8 and A/9
4) Aswad. black seed A/10 ...

Progeny of these selections were grown in isolation to compare their potential yields and other characters. Brown, dark-brown, white and dark-grey progenies of the variety Wad el Neil Heavy black gave yields of 692, 617, 601 and 522 kg/ha, respectively. Such variation indicates the very rapid increases in yield that can be obtained by relatively simple selections in the local cultivars. Most of these strains are distributed as germplasm to different international institutions and used in the different breeding programs.

3) Variety evaluation

From the early 1960's up to now, variety trials have been conducted to evaluate the performance of both local and imported varieties in the East African countries separately. With very few exceptions, (e.g. the variety Morada in Tanzania), the results of these experiments have shown that the local varieties outyielded all other imported varieties. In the Sudan for example, about seven varieties from the local collection outyielded the standard variety, while only one variety from the large number of introductions gave yield similar to that of the control.

Efforts to develop improved non-shattering varieties for mechanical harvesting in the Sudan and Tanzania were completely failure. Rio and Palmetto, both commercial and non-shattering varieties, gave low yield (less than 50 kg/ha) in these two countries. Crosses involving indehiscent varieties with local lines also proved to be low yielders. The attempts to transfer indehiscence to standard local varieties were discontinued and the work was directed to develop high yielding dehiscent types with all pods on the plant maturing at the same time which will offer a solution for partial mechanical harvesting. On these bases, about five local varieties were released to farmers in Sudan.

From the results of the variety trials carried out in the East

African regions, where the local varieties showed superiority over the introduced varieties, the future work must be based upon the importance of local adaptation in this crop (1, 2).

4. Agronomic practices

Agronomic research was directed towards some of the basic aspects of sesame production and recommendations were put out for growers. Summary of results of the agro-technical measures is reported hereunder:

Time of sowing: Although the sowing date, depending on the onset of rainy season, differs from region to region in the East African countries, investigations show that delaying sowing from the optimum sowing date results in high reduction of yields (14).

In Tanzania and the Sudan, according to the weather changes particularly rainfall pattern, the main sesame-producing areas could be divided into different agro-ecological zones on the basis of prevailing pattern and duration of rains during the growing season that influence the crop growth and the kind of varieties grown. Evaluation of varieties under these different zones was started in Tanzania (1978-1980) and the Sudan (1987-1988) using different breeding materials.

In Tanzania the cultivars used were divided into four groups: - late maturing, medium maturing, early maturing and extra-early maturing. It was proposed that with this wide range of maturity periods, it would be possible to select the suitable varieties for a specific zone.

In the Sudan, late maturing, medium maturing and early maturing varieties tested over four sites under three sowing dates, indicated that early sowing gave higher yields than late sowing. Also the late variety was more sensitive to late sowing than the early and medium maturing varieties (1). The same results were reported in Tanzania (5).

Plant population: The African varieties branch profusely and can compensate for a wide range of plant densities. Field trials indicate that higher yields are achieved at higher plant population exceeding 100,000 plants per hectare (8, 9).

Trials in Uganda have shown the superiority of row-sowing over broadcasting to control weeds and this factor alone has resulted in a considerable yield increases and spacing at 60x8 cm is officially recommended.

Weed control: Hand weeding is the usual practice in the countries under consideration, but it is not always carried out. In the central clay plains of the Sudan, yield is directly related to the timeliness and effectiveness of weeding (10).

In Ethiopia, field trials indicated that, the critical period of weed competition was during the first 4-5 weeks after crop emergence (11). The crop showed a good response to a single early weeding thereafter producing sufficient canopy to suppress further growth and development of weed. High yields of this crop can be realized if only early weeding is practiced.

Resistance to sesame web worm: Evaluation of different sesame strains for their differential response to sesame web worm (*Antigastra catalaunalis*) indicated that the local Sudanese strains are generally less attractive to web worm than the introduced strains.

Package trials: It is encouraging that some national programs were devised to solve problems in the field of research by aggregating the highly diffused manpower into a working team so as to identify the technology underlying the potential oilseed production in the highlands of Ethiopia.

In Egypt, trials on farmers' fields were planned jointly by scientists and extension workers, with the operations carried out by the farmers under the supervision of experts. The adoption of the package resulted in an increase of 165 kg/fed (3).

An observation that is worth mentioning is that, in the last season, a very restricted on - farm trial have been conducted over five farmers' fields in Abu Naama district (Sudan) using a promising monostem line (UCR origin). Although the variety showed good performance (2 m tall) and good yield, but the farmers drew our attention to new problems. The plants were too tall which should be cut twice or if cut once the bundles would be too long and hence could not withstand winds during drying. Another problem is that the stems are hard (woody), and difficult to cut by hand. Due to the nature of the stems (woody), they break when used to tie the bundles. Therefore the plant height and the nature of the stem are very important criteria judged by the farmers.

Research Priorities

Transfer of technology from laboratory to land

The adoption of improved varieties and production technology is required to increase the yields. Appropriate cultural practices, when individually worked out, may lead to yield increase of 10-20% and all combined may boost the production by more than 100% over the traditional method of cultivation (6).

For the majority of the regions in East Africa, this production technology has been identified. Also, under irrigated conditions, higher yield (1000-2000 kg/ha) was reported in the Sudan and Ethiopia.

However, recommendations of cultivars and cultural practices have not been communicated to the farmers. The most common reason is the lack of strong linkages between the researchers and the farmers and the result as observed is the wide gap between the yields reported by research stations' and obtained by the farmers.

New approaches to link the researchers and farmers may rectify the situation. In order to convince and motivate the farmers to accept improved technologies, demonstrations should be organized on farmers' fields.

The progressing extension system (T & V) in India, the package trials in Egypt and the working team in Ethiopia confirm the impact of close relationship between the research and extension in transferring the new approaches and techniques to the growers. Therefore, the activities should be directed to develop strong linkage between the researchers and farmers in the African countries.

Tropical nursery for sesame germplasm

Varietal evaluation work has shown that the African local varieties are superior to imported varieties and there is a wide variation in yields and maturity duration within the different landraces. Such variation indicates the very rapid increase in yields that can be obtained by relatively simple selection within the local varieties. To achieve this, it will be necessary to collect several strains of the local varieties within the region followed by an intensive selection program.

Intensive germplasm collection, confined to small geographical area of Nuba Mountains in the Sudan, illustrates that there can be, within a small area, great variation in phenotype as well as genotype and adaptability. Hence, collection of just few samples could not possibly reflect the diversity or represent the germplasm of the vicinity (4). These suggest that collection and exploration should be carried out in the tropical savanna and dry tropical areas of Africa starting with the major producing countries, the Sudan, Ethiopia, Uganda, Tanzania, Nigeria and others.

There is a great need for tropical nursery where complete collection of tropical materials in Africa can be grown, evaluated, increased for distribution and stored under suitable conditions for long-term preservation. In the Sudan, such nursery was built since early 1960s where large number of indigenous and exotic varieties were collected, evaluated and preserved in cool room. Hopefully, this will need to be supported.

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CONSTITUTION OF THE OIL CROPS NETWORK

(Second Draft)

Masood A. Rana and Abbas Omran

The first draft of the constitution was carefully and thoroughly discussed in the General Steering Committee Meeting held at Hyderabad, India from January 16-17, 1989. Each clause of the first draft was open to the house for suggestions /amendments. In this process the appropriate suggestions were incorporated and second draft was prepared at the end of the meeting which is now being circulated for information and critical review by the member countries.

This document will be presented in the coming meeting of the Whole-Network and will be enforced after approval of the house.

TITLE OF THE DOCUMENT

Constitution of the Oil Crops Network for East Africa and South ASia.

1. PURPOSE OF THE NETWORK

To improve/develop the annual oil crops especially those not covered by other international research organizations through better coordination and cooperation among the oil crop growing countries and strengthening their research program for the benefit of farmers.

2. OBJECTIVES

i) To assist member countries for the improvement/development of rapeseed-mustard, sesame, niger, sunflower, safflower and linseed.

ii) To enhance the general productivity and production of the mandate crops in different situations and systems.

3. APPROACH

i) To enhance the research capabilities through firsthand contacts, exchange of information and materials, dissemination of knowledge, organization/participation in meetings, workshops, seminars, publication of newsletters and trainings.

ii) Locate financial assistance and provide consultancy in the needed areas.

4. STRUCTURE

The Network will consist of the present four working units under the overall umbrella of whole-Network as below:

1) Subnetwork on brassica.
2) Subnetwork on sesame.
3) Subnetwork on sunflower.
4) Subnetwork on other oilcrops (linseed, safflower and niger).

Other oilcrops may be added in the future.

5. OPERATION

Each subnetwork will be managed through a Steering Committee. The Whole-Network will be operated through a General Steering Committee. The Steering Committees of each Sub-Network will formulate its work plan.

6. COMPOSITION OF STEERING COMMITTEES

i) Subnetwork

a) The Steering Committee of a Subnetwork will consist of 5 members, representing the two regions (E.Africa and S.Asia) in a ratio of 2:3, alternately.

b) Network Advisor will serve as Member Secretary.

c) Each Steering Committee will be headed by a Chairman and a Co-Chairman, one from each of the two regions.

d) One or two special invitees as recommended by the Steering Committee to fill in critical gaps.

ii) Whole-Network

a) Chairman and Co-Chairman of the four Sub-Networks.

b) Advisor of the Network and one or two representatives from the donor agencies.

7. ELIGIBILITY FOR THE MEMBERSHIP OF STEERING COMMITTEE

i) Scientists actively involved in the crop/crops in a research organization or donor supported projects will be eligible for the membership of the Steering Committee of Subnetworks, subject to the approval of the respective Government authorities.

ii) One country can contribute only one member to each of the Steering Committees.

8. ELECTION OF CHAIRMAN, CO-CHAIRMAN AND OTHER STEERING COMMITTEE MEMBERS

i) Each of the Sub-Network Steering Committees will elect its Chairman and Co-Chairman, one from each region.

ii) The Network Advisor/Secretary, after election, will inform the concerned Government/ authorities about the elected member and seek the assurance of the possible participation of the member, so elected, in the Network meetings and other activities.

iii) In the third meeting of each Subnetworks, two members shall forgo their membership voluntarily or by drawing lots. To fill the vacant places 2 new members will be elected. Either the Chairman or the Co-Chairman can continue for the next meeting.

iv) The new Steering Committee shall then elect Chairman/ Co-Chairman whoever was dropped in the process mentioned in clause 8(iii).

v) In the fourth meeting three members who continued from the beginning shall drop and in their places new members shall be elected.

vi) Subsequently, in every meeting of the Subnetwork either two or three members shall be elected or re-elected following the procedure mentioned above.

9. CONTACT PERSON

The Steering Committee member shall be the appropriate contact person. Wherever a member country is not represented in the Steering Committees the Network Advisor shall approach the respective Government authorities to nominate one scientist actively involved in the development and research of the mandate crops as the contact person.

RESPONSIBILITIES OF STEERING COMMITTEE AND CONTACT PERSON

i) Steering Committee

a) Chairman and Co-Chairman will be responsible to finalize the plan of work with the consultation of Sub-Network members, accompanied with a budget estimate.

b) Chairman shall monitor the progress of the approved technical program. He may delegate authority of part of monitoring to the Co-Chairman or any member of the Steering Committee or the Network Advisor whenever needed.

c) Prepare the final report indicating the achievements and progress and present it to the Sub-Network meeting.

d) Identify the critical constraints holding the implementation of technical work plan.

e) Screen the technical proposals on the matters of interest to the member countries and send them to the Netwrok Advisor for locating the financial help.

ii) Contact Person

The Contact Person will be responsible to provide and receive information on Network matters and country situation.

11. FREQUENCY OF THE MEETINGS

i) Subnetwork shall meet once every 18-24 months, while the Whole-Network once after 3 to 4 years.

ii) The Steering Committee of the Whole-Network shall meet once every year along with any of the Subnetwork meetings.

12. PROGRESS AND FOLLOW UP ACTION

Each subnetwork, in its meetings, shall review the progress and achievements for the period between the last meeting and ongoing meeting, and formulate the future action plan on the basis of immediate priorities.

13. CONSTITUTIONAL AMENDMENTS

i) Amendments in the constitution shall be made by the full body of the Whole-Network.

ii) A minimum of 75% votes of the total Whole-Network strength will be required to accept any amendment.

iii) When a need of change in the constitution is felt, it should be conveyed to the Network Advisor in writing who will circulate the proposed change to the members of Whole-Network for information and their input.

iv) The required change, then will be presented in the coming Whole-Network meeting for approval.